REPRODUCTIVE BIOLOGY OF A LEPIDOPTEROUS PEST

DISSERTATION
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

Master of Philosophy

IN

AGRICULTURE
(ENTOMOLOGY)

BY

RUBINA HAFEEZ

INSTITUTE OF AGRICULTURE
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

1993

Dedicated
To My Parents

DEPARTMENT OF ZOOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH, U.P. INDIA
202002

Phones {University : 285; Public : 25646}

Sections :
1 ENTOMOLOGY
2 PARASITOLOGY
3 ICHTHYOLOGY & FISHERIES
4 AGRICULTURAL NEMATOLOGY
5 GENETICS

Ref. No. ....

Date 15 October, 1993

This is to certify that the dissertation for M.Phil. degree in Agriculture of the Aligarh Muslim University, Aligarh has been completed by **Ms. Rubina Hafeez**, under my supervision. It is original in nature and I have permitted the candidate to submit it in partial reuirements for the award of the degree.

Humayun Murad

(**HUMAYUN MURAD**)

Supervisor

CONTENTS

PAGE NO.

Acknowledgement

I INTRODUCTION 1

II MATERIAL AND METHODS 5

III REVIEW OF LITERATURE 9

IV RESULTS (Biology)

i) Egg 13

ii) Larval instars I-VI 14

iii) Pupa 18

iv) Adult 19

V. DISCUSSION 24

VI. RESULTS (Food Consumption and Utilization).... 30

i) Consumption index 32

ii) Growth rate 32

iii) Efficiency of conversion of ingessted food 33

iv) Efficiency of conversion of digested food 33

v) Approximate digestibility 33

VII. DISCUSSION 35

VIII. REFERENCES 38

ACKNOWLEDGEMENT

It gives me immense pleasure and honour to express my deep sense of gratitude to **Prof. Humayun Murad** who has guided me with scholarly patience and aplomb. **Prof. Murad's** wide experience and knowledge in Entomology and his willingness to share it with me was of great help in completing the present work.

I am greatly indebted to **Prof. M.Shamim Jairajpuri**, Director, Institute of Agriculture and **Prof. Man Mohan Agarwal**, Chairman, Department of Zoology for providing necessary facilities. Special thanks are extended to **Mrs. Naushaba Murad**, Reader, A.M.U. Women's College, for being the constant source of encouragement and moral support during the course of this work.

I am highly thankful to my senior **Dr. Archana Bansal** and colleagues **Ms. Robina Naseer** and **Mr. Arshad Ali Siddiqi** for their critical suggestions and valuable contributions. It is my pleasure to thank my colleague **Mr. Mohd. Amir** who sacrificed his valuable time and without his constant help the present work would have not been completed.

I remember with gratitude the help rendered by **Mr. Khwaja Jamal** in the field collection, culture maintenance and the photography of the experimental insect.

Most cordial thanks are due to my friends **Ms. Subuhi Khan** and **Mrs. Dipender Vohra** for being generous with support and encouragement whenever I needed.

On a more personal note I wish to thank my eldest brother **Dr. Anwar Ghani**, Senior Scientist, Ministry of Agriculture & Fisheries, New Zealand, whose encouraging comments and suggestion provided me with the confidence and capability to bring this work to completion.

I would like to express my sincere gratitude to my family particularly to my parents, whose teachings of hard work and discipline have inspired me throughout the arena of my study.

Finally I would like to express my thanks to **Mr. Kafeel A. Khan** and **Mr. Abid Ali** for taking pains in meticulously typing the manuscript.

Above all I am thankful to **Allah** almighty for giving me the opportunity and strength to complete this work.

R. Hafeez

(RUBINA HAFEEZ)

INTRODUCTION

India is predominantly an Agricultural land with nearly 70% of its working population engaged in Agriculture. It accounts for about 40% of the total National income and is therefore the mainstay of Indian economy. Therefore, the speedy development of agriculture is vital to the progress of our country. For securing maximum crop production the best use of the knowledge of the latest tools and techniques has to be done. Our country having varied climatic conditions is in unique position to grow almost every possible crop and occupies an outstanding position in the world with respect to several agricultural products.

Insects are the chief rivals of human beings and their unceasing struggle is continued because of the fact that both man and certain insects constantly require the same thing at the same time. In an attempt to secure food, the insects inflicit considerable damage to every part of the plant causing an indirect effect on the economy of the country. Insects affecting the crops are causing two fold damage to our economy, one by affecting the quality and reducing the quantity of the product and the other by requiring the investment of money and involvement of mechanical and manual labour for their proper control measures. The insects have an intimate relationship with the plants. The more luxuriant and varied the flora, the more abundant and diversified its accompanying insect fauna.

The seriousness of the attack is decided by the nature of the injuries inflicted, the susceptibility of the plant to the attack, the feeding efficiency and the host plant relationship. The insects cause damage at various levels, starting from the field upto the storage. The losses caused by insect pests are 20-35% out of which 12-15% is contributed by the stored grain pests alone (through personal communication from the Plant Protection Department, Ministry of Agriculture). There is a significant lowering in the losses caused by insects in recent years because of the advancement in the scientific knowledge and awareness of the farmers.

Among the diverse forms of insects infesting agricultural crops, those belonging to Lepidoptera are very important. Though no accurate estimate of the annual losses caused by Lepidopteran pests in value of the product is done in our country, but it has to be admitted that the extent of damage may occasionally be considerable. Very little information is available as to the exact identity of the pest species and their relative importance.

For an effective and economical application of different methods of control so far known, it is essential to have proper idea of the insect pest (identification and biology) one has to deal with. The knowledge of the life history of an insect will be very helpful in adopting such measures against any pest. The biology or the life cycle of an insect means the record of all that the insect habitually does and all the changes in form and habits that it undergoes from the beginning of its life until its death, including the situations where each life stage and every season is spent and the length of the time occupied by each stage.

The hairy caterpillars or the "Wooly Bears" are well known foliage feeders. Many of them feed exposed on the leaves while others feed within the rolled or folded leaves. The Bihar hairy caterpillar, *Diacrisia* (= *Spilosoma*) *obliqua* Walker belongs to the family Arctiidae. The members of this family are found devouring the foliage of almost any low growing crop, but a few of them are very specific. *D. obliqua* is a polyphagous pest, widely distributed throughout the country, found very commonly in Uttar Pradesh, Madhya Pradesh, Bihar and Punjab (Atwal, 1986). It causes considerable damage to pulses, cotton, vegetables, sorghum, maize, ragi, oil seeds, small millets, sugarcane, pady, wheat, guinae grass, jute, sunhemp, beet-root, potato, and sweet potato (Mathur, 1962; Pant, 1964). Besides, they also attack other agricultural and fibre crop as well as medicinal plants (Pant, 1964).

For the assessment of the damage caused, insect plant relationship, ecological success and the control measures required for a particular pest, it is essential to have a basic knowledge of identification abundance, distribution, food range, damaging stage, damaging potential, mode of damage, life history and the nutritional ecology.

Most of the work done in the area of nutritional ecology was based on the food preference, preparation of artificial diets or on the total utilization profile. But for the better understanding of the insect plant relationship and the success of the pest in the ecosystem, it becomes all the more important to work in detail the food consumption, utilization, digestibility and conversion of food into body tissues. Food consumption, in addition to accounting for the quantitative loss brought about by the pest species also serves as an indirect measurement of the relative susceptibility of food plants.

Keeping in mind immense economic importance, pest status and its ecological success, it has been desired to study the biology and consumption, assimilation and utilizaton of castor leaves (*Riccinus communis*) by the larvae of *D. obliqua*. The present work is divided in two parts, the first one deals with the biology and the second accounts for the quantitative food consumption and utilization.

MATERIALS AND METHODS

The culture was started with the eggs which were collected from the field during the spring season. The rearing was done in glass jars measuring 12" x 8". The larvae of Diacrisia obliqua Wlk. were reared on castor (Riccinus communis) leaves at 27±2°C temperature, 65±5 relative humidity and 12:12 hrs. photoperiod. The food was supplied twice a day and the hygienic conditions were maintained by cleaning the jars daily. To avoid overcrowding the number of larvae per jar was restricted to 100-200, I-II instar and 30-50, III-VI instar larvae. The adults were fed on 10% glucose solution soaked in cotton changed daily to avoid fungal growth. Folded paper strips were placed in the jars containing the adults for oviposition.

The biological cycle of the pest was started from the freshly hatched larvae (in three replicates of five each) and was completed on the same stage by passing through a series of larval instars, pupa, adult and the egg. The individual specimens were isolated from the mass culture for the detailed morphological studies.

The quantitative assessment of food consumption digestion and utilization was done by using Waldbauer (1968) procedure with slight modification. The food consumed, excreta voided and the weight gained by individual larvae from III to VI instars were determined on dry weight basis.

The method involves the isolation of freshly moulted larvae from the mass culture. These were daily supplied with fresh castor leaves (weighed wet) for three consecutive days. The left over wet leaves and the excreta voided were weighed the following day. The difference between the fresh leaves and the left over leaves gives the net weight of the leaf consumed. For finding out the dry weight of the food consumed, equivalent amount of fresh leaves were placed in an oven for one hour at 100°C and then at 60°C until the weight became constant. The excreta voided was also dried by using the same method. The difference between the amount of food consumed and the feces produced is the weight of the food digested.

The fresh weight of the larvae was determined at the beginning of each experiment. The dry weight of each larva was estimated by using the mean percentage dry matter of an aliquot of like larvae which were killed by chloroform and then dried in an oven (at 100°C for 1 hr and at 60°C till the weight became constant). The difference between the final dry weight of the larva when sacrificed after the moult and the estimated initial dry weight was the net weight increased. The amount of food consumed or digested in relation to the increase in body weight is a measure of the efficiency of utilization.

The experiment was set in three replicates of five each for three consecutive days per larval instar at 27±2°C temperature, 65±5 RH and 12:12 hrs. photoperiod.

In the expression of the result following indices were used :

The approximate digestibility (A.D.) is calculated as :

$$A.D. = \frac{F - E}{F} \times 100$$

The growth rate (G.R.) is expressed as :

$$G.R. = \frac{G}{T\ A}$$

The consumption index (C.I.) is calculated as :

$$C.I. = \frac{F}{T\ A}$$

The efficiency of conversion of ingested food to body matter (E.C.I.) is a measure of the overall ability of the organism to grow on a given food. It is calculated as :

$$E.C.I. = \frac{G.R.}{C.I.} \times 100 = \frac{G}{F} \times 100$$

The efficiency of conversion of digested food to body matter (E.C.D.) is calculated as :

$$E.C.D. = \frac{G}{F-E} \times 100$$

Where F represents the dry weight of the food ingested per larva per three days, E is the dry weight of the excreta voided per larva per three days, G expresses the dry weight gained per larva after feeding, T is the time of feeding and A is the mean dry weight of the initial, final and intermediate weights divided by the number of weighings. Since the larvae on various fresh leaves ate and grew at different rates over variable periods, therefore it became necessary to express all measurements in a form which made possible the comparison of intake and efficiency of utilization.

REVIEW OF LITERATURE

Diacrisia obliqua Wlk. is an important pest of various crops in India. The larvae of this moth are polyphagous and voracious feeders of the foliage. It has been reported from all over the country to cause considerable damage to pulse, cotton, vegetables, sorghum, maize, ragi, oil seeds, small millets, sugarcane, paddy, wheat, guinae grass, jute, sunhemp, beat root, potatoes and sweet potatoes (Mathur, 1962 and Pant, 1964).

It has been reported as the most destructive pest of soybean (Gangrade, 1976, 77; Bhardwaj & Bhalla, 1977; Ram & Bhattacharya, 1978; Khaleque, 1983; Haq et al., 1984, 85 and Ali, 1988). It causes significant damage to oil seed crops like groundnut, castor, mustard and sunflower. It has been reported on groundnut by Srivastava et al. (1965), Sethi et al. (1979), Pachori et al. (1980), Islam et al. (1983) and Vora et al. (1985). It has been reported on mustard by Bakhetia & Brar (1982) and Bakhetia (1986); on castor by Srivastava et al. (1972) and Singh & Gangrade (1974) and on sunflower by Rohilla et al. (1981) and Srivastava & Pandey (1987).

It has been found damaging jute by Sharif (1962) and Tripathi (1967), on maize by Verma et al. (1977). Among pulses it has been found causing severe damage to moth bean (*Phaseolus acontifolius* Jacq.) (Puttaswami et al., 1977), french bean (*P. vulgaris* L.) (Puttaswami & Reddy, 1981), as seasonal pest on green gram (*P. aurenis* Roxb.) (Sinha et al., 1985) and on mungbean (Lal, 1985). Its incidence has also been reported on blackgram (*Vigna mungo* L.) (Dhuri et al., 1984) on cowpea (*V. sinensis* Savi) (Yadav & Yadav, 1983), on chicken pea (*Cicer arietinum* L.) (Deka et al., 1987).

It has been found attacking some ornamental plants and vegetables (Gargav & Katiyar, 1971 and Sachan, 1981). It has been reported on chinese potato (*Coleus parviflorus*) by Palaniswami & Pillai (1983), on raddish by Butani & Juneja (1984). Among ornamental plants, the flowers of *Gladiolus* and leaves of globe artichoke (*Cynara scalymus*) are very prone to its attack (Krishnah et al., 1975). Its incidence has also been reported on few medicinal plants by Mathur (1962).

An other species *S. lubricipeda* has been reported on apple and pear foliage by Sengalevich (1960) and *S. virginia* was found very common on weeds (Rizzo, 1978, 79). The larvae of *D. obliqua* have been deployed to control the cosmopolitan weed *Lantana* (Benson & Chatterjee, 1940).

D. obliqua being a polyphagous pest consumes a variety of food. These foods have variable effect on their growth, development, nutrition and reproduction (Babu et al., 1978; Gupta et al., 1979; Prasad & Prem Chand, 1980 (a & b); Deshmukh et al., 1982; Gupta, 1982; Srivastava & Pandey, 1983; Goel et al., 1986 and Kabir & Miah, 1987).

Morphological studies of the adults have been done by Ahmad & Ahmad (1976) and the larval morphology was studied by Goel & Kumar (1983), biology and larval morphology of S. virginia (F.) was studied by Rizzo (1978, 79).

The bioecology of D. obliqua has already been done on a number of host plants. Temperature has been found as one of the most important ecological factor which affects the growth and development of the insects (Singh & Gangrade, 1974; Bhat & Bhattacharya, 1978, and Chaudhary & Bhattacharya, 1986). The other ecological factors like photoperiod and light intensity do have significant effect on the premating behaviour or the calling rhythm of the arctiid moths (Webster & Conner, 1986). Details of mating and oviposition of D. obliqua have been studied by Islam & Alam (1980), Husain (1982) and Siddiqi (1985, 88). Observations on the biology, larval and pupal durations adult emergence, longevity and the percentage mortality of adults have been worked out by Sinha & Gangrade (1974, 77), Babu et al. (1978), Deshmukh et al. (1982), Srivastava & Pandey (1983) and Chaudhary & Bhattacharya (1986).

The efficiencies of consumption and utilization of ingested and digested food has been worked out in a few Orthopteroid and Lepidopterous insects (Waldbauer 1964, 68). Among Orthopteroids, the food consumption, assimilation and tissue growth have been studied by Chlondy (1967), Bennakkars et al. (1970), Mordue & Hill (1970), Mehrotra et al. (1970), Khalsa (1973), Gupta & Vats (1980), Simpson (1982) and Vir & Jindal (1983). Among Lepidopteran insects the ecological efficiencies, food consumption, utilization, growth rate and the efficiencies of conversion of ingested and digested food has been worked out by Mukerjee & LeRoux (1969), Kogen & Cope (1969), Mathavan & Bhaskaran (1975), Bhat & Bhattacharya (1978), Mackey (1978), Haukioja et al. (1978), Ram & Bhattacharya (1978), Chand (1979), Babu et al. (1979), Prasad & Chand (1980), Valentine & Talerico (1980), Cohen & Patana (1985), Crocomoard & Parra (1985), Slansky Jr. (1985), Warrington (1985) and Sharma & Tara (1988).

REPRODUCTIVE BIOLOGY

RESULTS

The Bihar hairy caterpillar, Diacrisia obliqua Wlk. is commonly found abundant in and around Aligarh. These are capable of damaging a variety of crops like oil seeds, vegetables, fibre crops, fruits, ornamental plants and even the weeds. Because of its significant economic importance, this moth has been selected for the present study. The moths are active during night hours, get readily attracted to light and are strong and steady fliers for short distances.

EGG

The eggs are laid in batches either on the paper strips, sides of the glass jars or on the muslin cover in captivity. The freshly laid egg is firmly glued to the surface with the sticky secretions of the accessory gland. The newly laid egg is glistening, small and spherical in shape. It measures 0.75 mm in diameter and is light green in colour but undergoes a series of changes before eclosion. The colour changes from green to pale, redish brown, brown and finally black .(Fig.1&2). The outer covering of the egg becomes hard and translucent a few hours before hatching and the larva inside can easily be recognised from the exterior. The incubation period varies between 173.15-215.15 hrs. with an average of 198.33±23.24 hrs. The percentage of eggs successfully hatched (eclosion) is 98.8%. The eggs usually hatch in masses.(Table-1, Fig. 13).

FIRST INSTAR LARVA

The first instar larva is a minute creature with a symmetrical body. It is pale yellow in colour with brownish head and gives a greenish reflection after feeding on the leaves. They bear five pairs of prolegs from third to sixth and the last abdominal segment. The body remains covered with setae and hairs, pre-spiracular wart of the prothorax with three setae. The setae and hairs are not visible with the nacked eyes (Plate-II, Fig. 3).

The full grown first instar larva measures 3.8 mm in length and 18.15 mg. in dry weight. The average first instar larval duration ranges 84.82±20.22 hrs. (Table-1, Fig. 13).

The newly hatched larva shows wriggling movement and wanders around the container in search of food. It feeds on the mesophillic tissues of the leaves, leaving the vascular ones and thus act as skeletonizers. If there is scarcity of food, these larvae consume the entire leaf and become the defoliators. When disturbed they hang themselves with a silken thread which also help them in the dispersal. The larvae are gregarious in habit.

SECOND INSTAR LARVA

The second instar larva can easily be distinguished from the first instar by having a characteristic cylindrical body. The newly moulted ones remain sluggish and are light yellow in colour but the active feeding stage is bright yellow with slight orangish tinge. The number and position of prolegs remains the same, the chrochets become prominent. The location and the number of setae on the prespiracular wart of the prothorax are similar to the first instar larvae. The hairs become prominent because of acquiring black colour (Plate-II, Fig. 4).

The actively feeding second instar larva measures 5.8 mm in length and 29.64 mg in dry weight. This stage lasts for 91.54±20.37 hrs(Table - 1, Fig. 13).

The feeding pattern is also very much similar to the first instar i.e. only consumes the mesophyllic tissues but the late second instar also consumes the secondary and tertiary veins (cortical and vascular tissue). When disturbed it drops suspended with the silken thread which is secreted by its mandibular glands.

THIRD INSTAR LARVA

The third instar larva is very slender, orange in colour with black spots on all the thoracic and the last two abdominal segments. The number and position of the prolegs, and the setae on the prespiracular wart is similar to the first and the second instar larvae. Warts of every segment become prominent because of the thickening of the cuticle in that area. The hairs and the setae can be distinguished into two types i.e. smooth and the spinose (Plate - III, Fig. 5).

The active third instar larva measures 11.4 mm in length and 38.52 mg in dry weight. This instar lasts for 127.00±12.29 hrs(Table - 1, Fig. 13).

These are gregarious and voracious feeders of the foliage causing severe damage to the crops. They consume entire leaf leaving only the midrib. When disturbed they try to drop themselves suspended with the silken thread which soon breaks up because of a significant increase in their body weight.

FOURTH INSTAR LARVA

The body is cylindrical, appears as a strong, stout and a hardy creature which are densely hairy. The colour is further darkened towards orange with very prominent black spots on the thoracic and the last two abdominal segments (Plate-III, Fig. 6).

The actively feeding larval stage measures 21.8 mm in length and 50.06 mg in dry weight. This larval instar lasts for 128.36±9.81 hrs(Table - 1, Fig. 13).

The feeding behaviour is very much similar to the third instar. When disturbed they try to escape from the area by fast crawling movements.

FIFTH INSTAR LARVA

The fifth instar larva is characterized by the tough and compact body having more dense hairs as compared to the fourth instar. The hairs appear in groups on the warts (become tufted) and are very long. Single hair measures 6-8 mm in length. The colour is bright orange with similar black spots as on the earlier instars but their is a prominent black band in the intersegmental area (Plate - IV, Fig. 7).

The full grown, actively feeding fifth instar larva measures 28.6 mm in length and 77.93 mg in dry weight. This stage lasts for 133.58±4.72 hrs(Table - 1, Fig. 13).

The feeding behaviour and the pattern is almost the same as in the third and the fourth instars but the amount and the rate of the food consumed is significantly increased.

SIXTH INSTAR LARVA

The sixth instar larva is distinguished by a slender, strong and stout body, resembling very much with the fifth instar larva in the colour, spots and the position of hairs. Because of the hairs being tufted there is a clear mid-dorsal streak which is slightly pale in colour ventrally. The larva is pale yellow with prominent intersegmental areas (Plate - IV, Fig. 8).

The last instar larva measures 30.75 mm in length and 117.61 mg in dry weight. The entire larval period including the pre-pupal period under controlled conditions varies between 212.44±5.88 hrs. Duration of the last instar alone is 138.85±2.54 hrs (Table - 1, Fig. 13). The feeding behaviour is similar to the earlier instars. It mostly feeds during night hours or in dim light and are voracious feeders and capable of devoring every soft part of the plant.

When the last instar larva attains the maximum size it ceases feeding and comes to rest, and after a break of 4-6 min. starts moving all round the container in search of suitable site for pupation.

PUPA

After selecting the suitable site the larva becomes confined and the structural modifications start appearing. The size of the last larval instar is almost reduced to half, the intersegmental grooves are deepened giving it an annular appearance. The hairs and streakes have almost faded out, the abdominal prolegs are reduced and the abdomen is tapering, this stage is known as pre-pupa.

The pupation generally takes place in the debris of the dead and decaying leaves, it has also been found pupating on the ground, in the soil (in field conditions), on the muslin cover or even on the sides of the glass jars in captivity. The pupation occurs within the silken cocoon interwoven with the shed off hairs of the last instar larva. The cavity inside is large enough to accomodate the pupa. The cocoon is very loosely woven and therefore in most of the cases the pupa comes out of it. There are pulsatory movements in the pre-pupa within the last larval moult. The posterior extremity of the pupa within the pre-pupal cast rotates, thus helping in the removal of the cast.

The newly formed pupa is tapering in structure and is pale yellow in colour but turns to leathery brown within 1-2 hrs. The abdominal segments start tanning first followed by the thoracic and cephalic segments. The female pupae are comparatively more tanned (Plate - V, Fig. 10). The full grown female pupa measures 19.6 mm in length and 3176.6 mg in weight, the male pupa being smaller in size measures 15.4 mm in length and 1750.4 mg in weight. There are 4-8 tubercles at the posterior extremity of the pupa in both the sexes (Plate-V, Fig. 9 & 10). The average pupal duration is 309.11±12.4 hrs. (Table - 1, Fig. 13). Hours before moulting the imago inside the pupa starts exerting pressure on the pupal moult and as a result prothorax splits mid-dorsally followed by the splitting of meso- and meta-thorax posteriorly and the vertex anteriorly.

ADULT

The body of the adult is robust and hairy, the head small inconspicuous, proboscis well developed and the palpi are short. They are bright orange in colour with a mid-dorsal and lateral rows of black spots from the second to the sixth abdominal segments with terminal spots becoming more prominent. Wings are buff orange in colour with minute black spots on the fore and very prominent spots on the lower margin of the hind wings (Plate - VI, Fig. 11 & 12).

Both the sexes are almost similar, the males are characterized by the presence of the pectinnate antenae. They are comparatively shorter than the females and measure about 15.2 mm in length and 36.8 mm wing expanse. Plate - VI, Fig. 11). The females are much bigger than the males and measure 18.6 mm in length and 45.6 mm wing expanse (Plate - VI, Fig.12).

The newly emerged adults take about 15-30 min. for the complete expansion of the wings. On their first flight they discharge a brownish fluid. The entire longevity of the adults can be divided in three stages:

i) Pre-Oviposition [pre-mating for the male]

ii) Oviposition

iii) Post-Oviposition

[Post-mating for the male]

Pre-Oviposition :

The pre-oviposition period is the time taken by the adults to reach the sexual maturity, the mating and the interval between the cesation of mating and the actual oviposition. The mating does not occur just after emergence of the adults. It takes about 12 hrs. time and a 10% glucose solution meal to attain the sexual maturity. The unfed females fail to produce viable eggs. When the matured male recognises the presence of the female, it becomes sexually excited. The state of excitation was reflected by some of its behavioural responses. The males start moving actively with rapid fluttering of antennae and wings. The abdominal tip is moved up and placed down repeatedly. These activities continue for 10-35 min.

The females in response show two types of behaviour, some of them start fluttering their wings with slight rhythmic movement (contraction and relaxation) in the anal area while others start moving slowly with their abdominal tips pressed on the surface of the container. Finally, the individuals of the opposite sex approximate each other by bringing their abdominal tips closed and then copulate in end to end position, remain interlocked for 0.10-1.15 hr. They can easily be separated by a slight pressure. The mating generally occurs during night or early morning hours. The young moths emerged, mate on the subsequent nights. The observations also reveal that the females mate only once in their life time whereas the males can mate more than once. The pre-oviposition period lasts for 19.11±0.42 hrs. (Table - 2, Fig. 14).

Oviposition

The phenomenon of egg laying does not occur just after the cesation of mating. It takes about 1-3 hr. for the females to get ready for oviposition. Before performing the actual act of oviposition the females show a series of behavioural responses. They become very active, start fluttering their wings, show rhythmic movements in the anal area and move fast all around the container till they become exhausted. Then after a pause of 10-30 min. start moving slowly with slight protrusion of the anal area and subsequent touching of the substratum to select the suitable oviposition site. After the selection of the ovisite the female stays there and shows peristaltic movement in the abdominal region before egg laying.

For the deposition of the egg the female brings abdominal tip close to the substratum and descends an egg out, then the abdomen is retracted with a slight jerk and the wings are slightly raised. The eggs get adhered to the substratum because of a sticky coating of the internal secretions. After laying an egg the female moves her abdomen on either side of it and lays the next egg. In this way the eggs are laid in an organised fashion in several rows with even spacing between the eggs.

In the case of virgin females the mechanism of oviposition is same but the pattern is entirely different. In most of them the eggs are laid scattered or in heaps which is an abnormal characteristic for this species. Most of the virgins do not have the urge of oviposition. The average oviposition period in the mated females is 117.17±41.5 hrs. (Table-2, Fig. 14).

Post-Oviposition :

The post-oviposition period is the duration between the cesation of egg laying and the mortality of the adults. It is very short and varies between 30.59±20.23 hrs. (Table - 2, Fig. 14).

Table - 1 : Showing the incubation period, egg eclosion, larval and pupal durations and the adult eclosion in *D. obliqua*.

	INCUBATION PERIOD (hrs.)	EGG ECLOSION (%)	LARVAL DURATION (hrs.)						PUPAL DURATION		ADULT ECLOSION (%)
			I	II	III	IV	V	VI	PRE (hrs.)	PUPAL (hrs.)	
1.	193.00		074.15	095.30	123.15	125.30	138.45	138.00	86.45	315.30	
2.	194.00		087.30	102.15	127.45	127.30	135.00	142.00	73.00	302.15	
3.	192.15		080.45	099.15	114.45	124.15	129.15	136.15	73.00	307.30	
4.	196.15		081.15	096.45	132.15	120.45	135.30	139.30	73.15	317.45	
5.	189.00		079.45	113.15	116.30	127.45	128.30	136.45	75.15	321.15	
6.	187.45		102.15	098.30	128.30	142.30	142.45	137.45	73.30	312.15	
7.	195.45	98.80±51.66	096.30	097.45	133.30	132.15	126.45	145.30	77.45	303.15	85.61±44.31
8.	193.30		079.30	090.45	125.15	118.15	136.15	143.45	69.30	305.30	
9.	192.30		086.30	100.15	136.45	134.45	133.45	138.30	73.00	315.45	
10.	190.15		088.45	106.15	134.45	128.30	132.00	136.15	73.00	312.30	
11.	180.00		095.15	089.45	127.15	133.30	127.45	143.15	74.15	394.30	
12.	175.45		096.15	092.30	124.15	136.15	134.30	141.45	73.45	308.15	
13.	215.15		075.00	094.30	138.15	122.45	136.15	138.30	72.30	308.00	
14.	173.15		078.15	097.45	118.15	125.45	137.15	135.15	73.45	312.15	
15.	188.30		073.00	101.15	126.30	128.15	132.00	132.45	76.15	299.30	
Average ± SD	198.33 ±23.24		084.82 ±20.22	091.54 ±20.37	127.03 ±12.29	128.36 ±09.81	133.58 ±04.72	138.85 ±02.54	73.22 ±1.24	308.90 ±12.74	

Table - 2 : **Showing the pre-oviposition, oviposition, and post oviposition period and the longevity of unmated and mated adults of *D. obliqua*.**

	PRE-OVIPOSITION PERIOD (hrs.)	OVIPOSITION PERIOD (hrs.)	POST-OVIPOSITION PERIOD (hrs.)	LONGEVITY OF ADULTS (hrs.)			
				UNMATED		MATED	
				MALE	FEMALE	MALE	FEMALE
1.	21.45	037.45	18.45	165.45	072.15	325.00	195.15
2.	17.15	125.15	17.15	288.00	128.30	186.15	362.45
3.	18.30	069.00	16.15	159.15	163.45	192.15	168.15
4.	19.15	097.15	38.00	223.30	212.00	190.30	259.00
5.	19.00	105.30	27.45	218.15	109.45	194.15	265.00
6.	19.45	086.15	22.15	195.45	206.15	165.45	286.15
7.	18.30	122.30	28.30	183.45	216.45	324.45	295.30
8.	20.15	125.00	20.15	179.45	212.45	288.00	128.15
9.	18.15	185.45	21.30	255.00	196.00	251.15	243.45
10.	18.00	179.15	27.15	234.00	199.15	215.30	188.45
11.	17.15	165.30	28.15	246.45	195.30	279.45	163.15
12.	18.45	153.15	19.45	149.45	185.45	338.15	315.00
13.	17.30	123.45	21.30	208.00	176.45	249.30	325.15
14.	17.15	098.15	24.45	275.15	168.15	264.15	318.15
15.	18.30	085.45	19.30	268.00	154.15	293.00	152.45
Average ± SD	19.11 ±0.43	117.17 ±41.58	30.59 ±20.23	216.56 ±47.09	172.98 ±42.36	250.81 ±78.38	243.63 ±13.67

DISCUSSION

In majority of moths if suitable conditions are available the pre-oviposition period is mostly very short as most of the eggs attain maturity during the later stage of pupal life. In D. obliqua this period varies from 19.11±0.42 hrs.Among other moths, the pre-oviposition period lasted 1-2 days in Thiacidas postica (Mehra & Shah, 1970) and Macalla monucusalis (Krishnamurthy et al., 1974). The preoviposition period varies between 1-3 days in Nephopteryx leucocephalla (Shah & Mehra, 1966), 54 hr. in Spodoptera mauritia (Murad, 1969), Anomis flava (Rao & Patel, 1973) and Cnaphalocrocis medinalis (Velusamy & Subramanium, 1974). The pre-oviposition period of 1-4 and 2-18 days in Heliothis armigera (Singh & Singh, 1975), Amarasca bigutella bigutella (Singh, 1978) respectively, and varies between 2-3 days in D. obliqua (Siddiqi, 1986).

The moths lay their eggs either singly or in clusters and a few show both the patterns. In the present study the females of D. obliqua laid their eggs in batches like that of Andraca bipunctata (Banerji, 1971), Chilo zonellus (Trehan & Butani, 1949), T. postica (Mehra & Shah, 1970) and D. obliqua (Siddiqi, 1986). On the other hand the females of Parnara mathias (Teotia & Nand, 1966), Hemithea tritonaria (Mehra & Shah, 1966) and H. armigera (Singh & Singh, 1975) laid their eggs singly. The pattern of both the type was reported in the females of Phyllocnistis citrella (Pandey & Pandey, 1964), M. moncusalis (Krishnamurthy et al., 1974), Polymatus boeticus (Pandey et al., 1978).

The females of D. obliqua laid their eggs during night hours. The nocternal ovipositional behaviour has also been reported in P. citrella (Pandey & Pandey, 1964), H. tritonaria (Mehra & Shah, 1966), N. leucocephalla (Shah & Mehra, 1966), T. postica (Mehra & Shah, 1970), A. bipunctata (Banerji, 1971), M. moncusalis (Krishnamurthy et al., 1974), H. armigera (Singh & Singh, 1975) and D. obliqua (Siddiqi, 1986). Where as in C. zonellus, the eggs were laid only in evening (Trehan & Butani, 1949) and females of P. boeticus oviposited in the bright day light (Pandey et al., 1978).

In the present study the oviposition period in D. obliqua was 117.17±41.58 hrs. Whereas the duration for the deposition of eggs in a single batch was 20-268 min. but it corresponds to the number of eggs in them. The oviposition period in moths is subject to great variation. It is 1-3 days in C. zonellus (Trehan & Butani, 1949), 1-11 days in H. tritonaria (Mehra & Shah, 1966), 2-4 days in P. mathias (Teotia & Nand, 1966) 4-5 days in T. postica (Mehra & Shah, 1970), 2-14 days in A. flava (Rao & Patel, 1973), C. medinalis (Velusamy & Subramanium, 1974), 2-5 days in H. armigera (Singh & Singh, 1975) and P. boeticus (Pandey et al., 1978), 4-28 days in A. bigutella bigutella (Singh, 1978) and 10.75±0.41 days in D. obliqua (Siddiqi, 1986). In the present study the incubation period in D. obliqua is 190.33±23.24 hrs. against the earlier 7.8 days at 25°C (Singh & Gangrade, 1974), 2.5-3 days (Lal & Mukherji, 1978). In H. armigera this period varies between 2.6-3.6 days with an average of 3.26±0.15 days (Singh & Singh, 1975) and 33 hrs. in S. mauritia (Murad, 1969).

The average larval duration is subject to great variation among Lepidopterans depending on various parameters like the environmental conditions, quality and quantity of food and the population densities. In the present work the average larval duration is 705.15±69.95 hrs. when the population density was 30 instars/jar (measuring 12" x 8"), fresh and excessive amount of food was supplied twice a day at 27±2°C temperature, 65±5 RH and 12:12 photoperiod. Whereas it is 33.7 days at 25°C (Singh & Gangrade, 1974), 19.9 days on Chenopodium album and 32.1 days in Brassica rugosa (Rathore & Sachan, 1978), fluctuates between 17-21 days in various varieties of black gram (Yadav et al., 1978), 20.88 days on sunflower and 24.5 days on groundnut (Prasad & Premchand, 1980), 28.5 days at 25°C and 24.5 days at 30°C (Deshmukh et al., 1982) and 34.34±0.38 days in Helianthus annulus and 40.33±0.54 days on Chrysanthemum frutescens (Srivastava & Pandey, 1987). In S. mauritia the average duration was 351 hrs. (Murad, 1969), H. armigera 10.8±0.73 days (Singh & Singh, 1975), Agrotis ipsilon 25-35 days

(Nikolov, 1980) and in H. virescens 15-21 days (Martinez et al., 1986).

In the present study the pre-pupal and the pupal period last for 73.22±1.24 hrs. and 308.9±12.74 hrs. respectively. The pre-pupal period was 12 hrs. in S. mauritia (Murad, 1969), 1-2 days in H. armigera (Singh & Singh, 1975), 1.5-1.8 days in D. obliqua (Rathore & Sachan, 1978) and 2-3 days in H. virescens (Martinez et al., 1986). The pupal period in D. obliqua is 10.5-8.3 days (Singh & Singh, 1974), 8.8-9.6 days (Rathore & Sachan, 1978), 9.5-11 days in different varieties of black gram (Yadav et al., 1978), 12 and 29.3 days on groundnut and cotton (Prasad & Prem Chand, 1980), 11.4-12.6 days at 25-30°C (Deshmukh et al., 1982) and 12.43±0.19 days on C. frutescens and 19.17±0.66 days on C. indicum (Srivastava & Pandey, 1987). In S. mauritia 164 hrs. (Murad, 1969), H. armigera 5-8 days (Singh & Singh, 1975) and 9-17 days H. virescens (Martinez et al., 1986).

The adults of D. obliqua emerge at dusk or at night as reported by Islam & Alam (1979) and Siddiqi (1985). The premating time in D. obliqua varies between 8-15 hrs. whereas it has been reported as 18 hrs. by Siddiqi (1985). On the other hand the moths of A. bipunctata mated immediately after emergence (Banerji, 1971). Whereas the moths of P. citrella (Pandey & Pandey, 1964), Lamporosema indicata (Kapoor et al., 1972) and H. armigera (Singh & Singh, 1975) matured for mating in about 14-24 hrs., one day after emergence and 36 min. to 32 hrs. respectively. It takes 1-2.5 hrs. for Hyphantria cunea to be ready for mating (Arai & Mabuchi, 1979). D. obliqua generally mate at night or at dusk i.e. their mating time coincides with the emergence time. Similar observations have been reported by Islam & Alam (1979) and Siddiqi (1985). In majority of the moths mating generally occurs during night such as P. citrella (Pandey & Pandey, 1964), C. medinalis (Velusamy & Subramanium, 1964), A. bipunctata (Banerji, 1971) and L. indicata (Kapoor et al., 1972). The Euxoa bilitura always prefers to mate and oviposit during light (Ripa, 1980).

The activities of excitement were shown by both the males and the females. Only the recognition of the presence of the female in the vicinity excites the male and the behaviour is reflected by its activities. In D. obliqua the fast movement and fluttering of wings occurs before mating. Similar responses have also been reported by Arai & Mabuchi (1979), Islam & Alam (1979), Kitamura & Koyama (1984) and Siddiqi (1985). The mating occurs in end to end position in D. obliqua. Similar observations have been found in Polytela gloreosae (Sachan & Srivastava, 1965), S. mauritia (Murad, 1969) and A. bigutella bigutella (Singh, 1978).

Mating in D. obliqua occurs only once in its life cycle which takes place before first egg laying. Similar observations were reported by Siddiqi (1985). Single mating throughout the life was also reported in P. citrella (Pandey

& Pandey, 1964) and *H. armigera* (Singh & Singh, 1975) but the moths of *L. indicata* mated more than once during their life time (Kapoor et al., 1972).

Plate-I

Fig. 1. Freshly laid egg batch of *D. obliqua* (X 1.3 mm).

Fig. 2. Egg batch of *D. obliqua* just before hatching (X 1.3 mm).

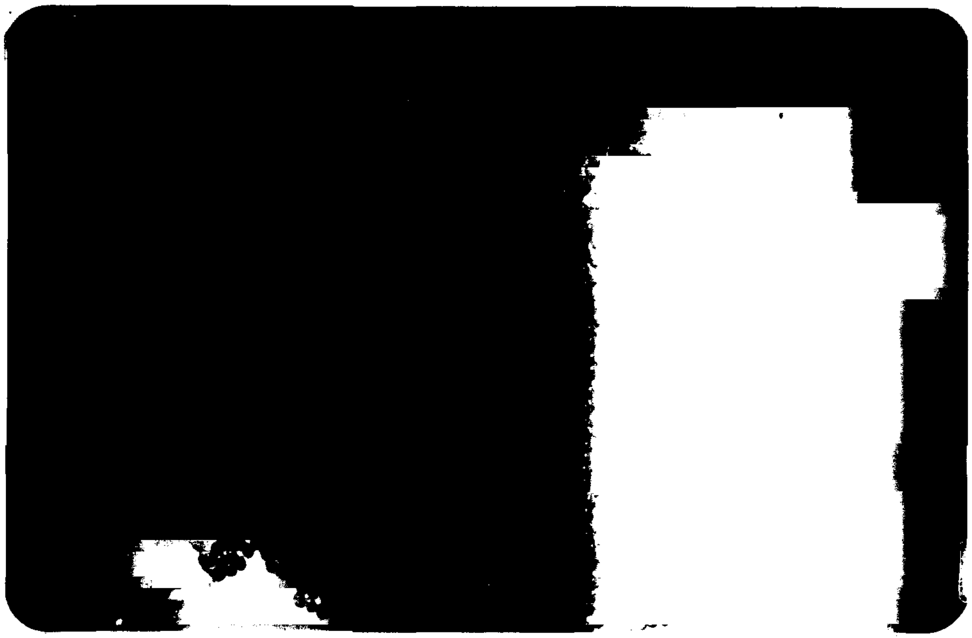


FIG.1

FIG.2

Plate-II

Fig. 3. First instar larva of *D. obliqua* (X 2.1 mm).

Fig. 4. Second instar larva of *D. obliqua* (X 3.45 mm).

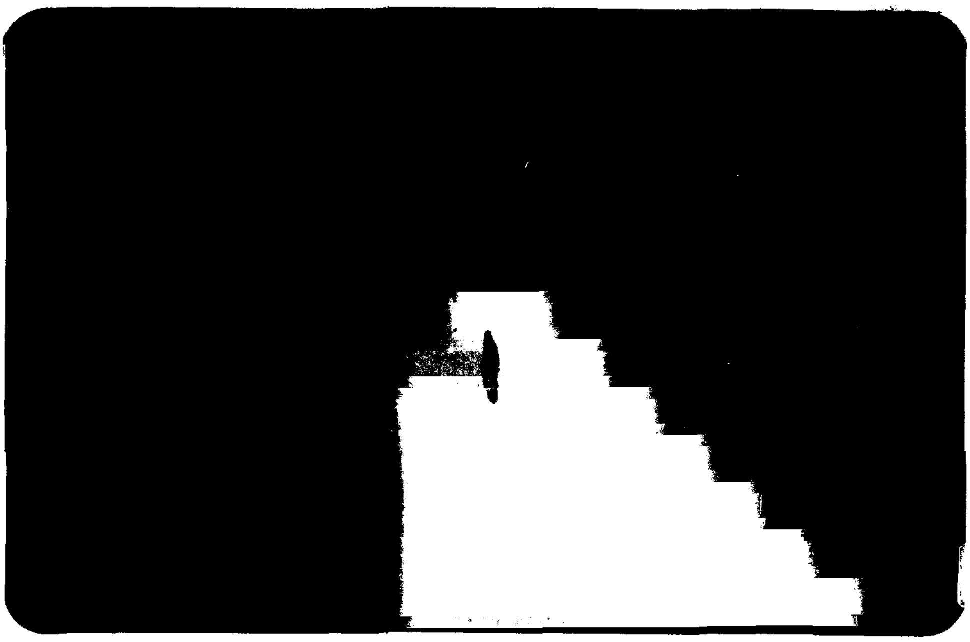


FIG.3

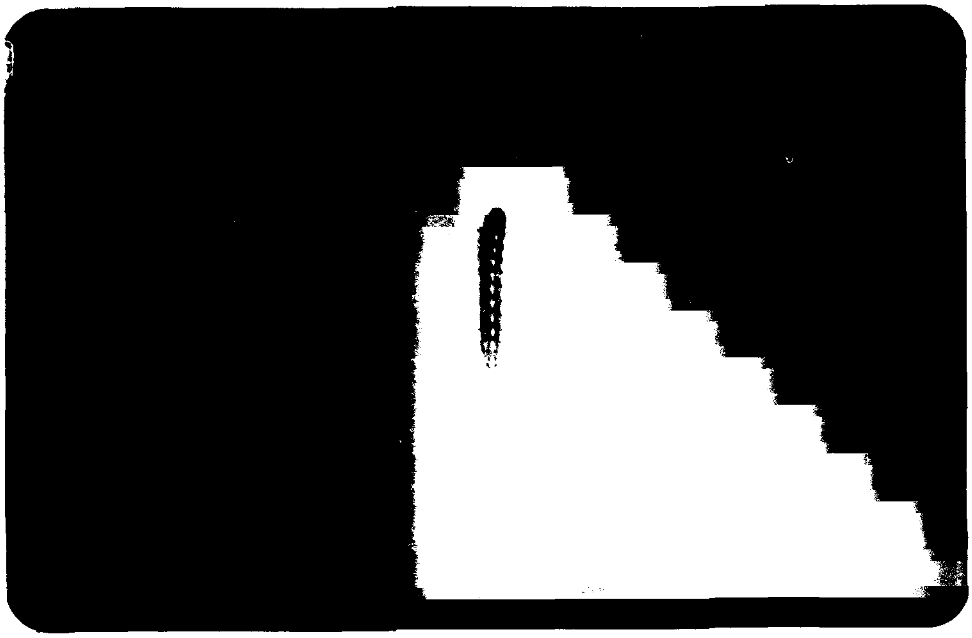


FIG.4

Plate-III

Fig. 5. Third instar larva of *D. obliqua* (X 3.15 mm).

Fig. 6. Fourth instar larva of *D. obliqua* (X 2.61 mm).

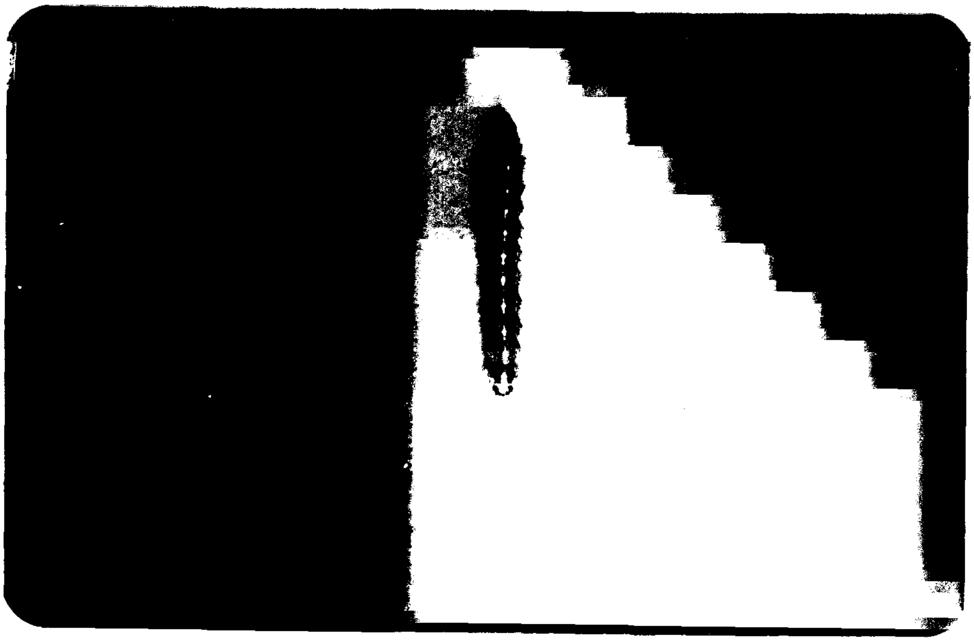


FIG.5

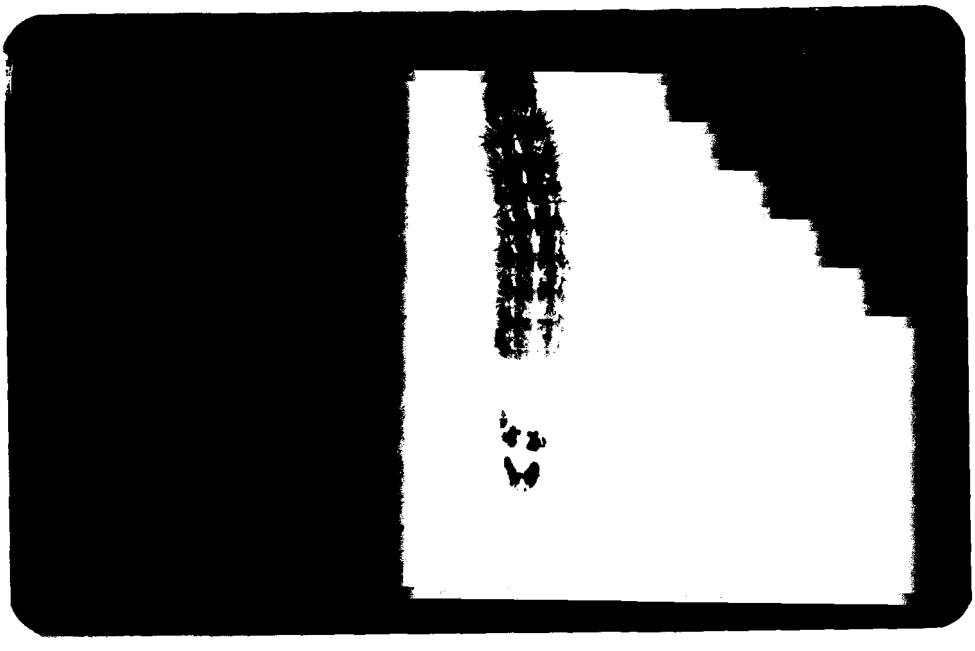


FIG.6

Plate-IV

Fig. 7. Fifth instar larva of *D. obliqua* (X 2.48 mm).

Fig. 8. Sixth instar larva of *D. obliqua* (X 2.7[illegible] mm).

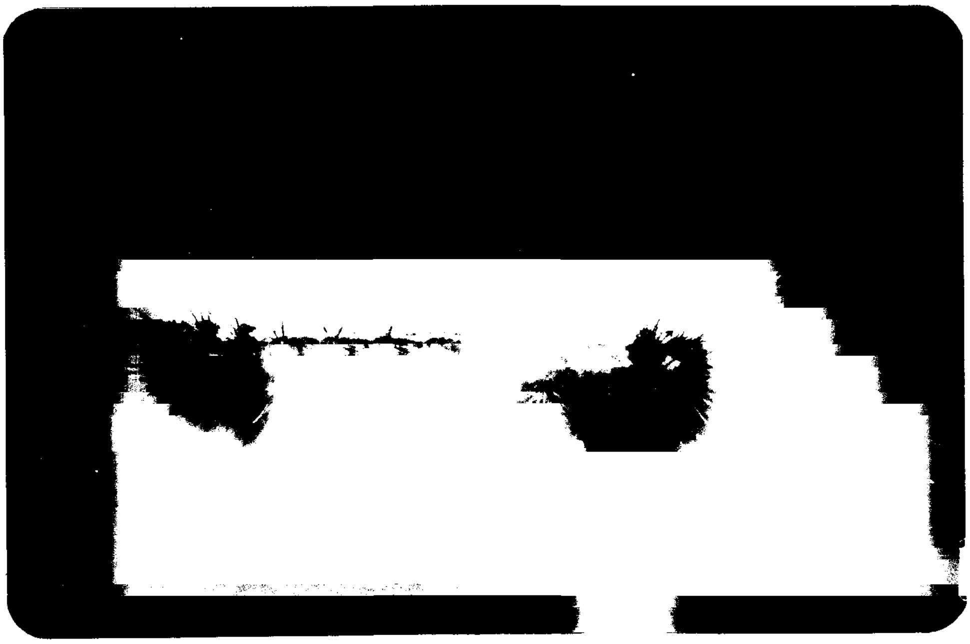


FIG.7

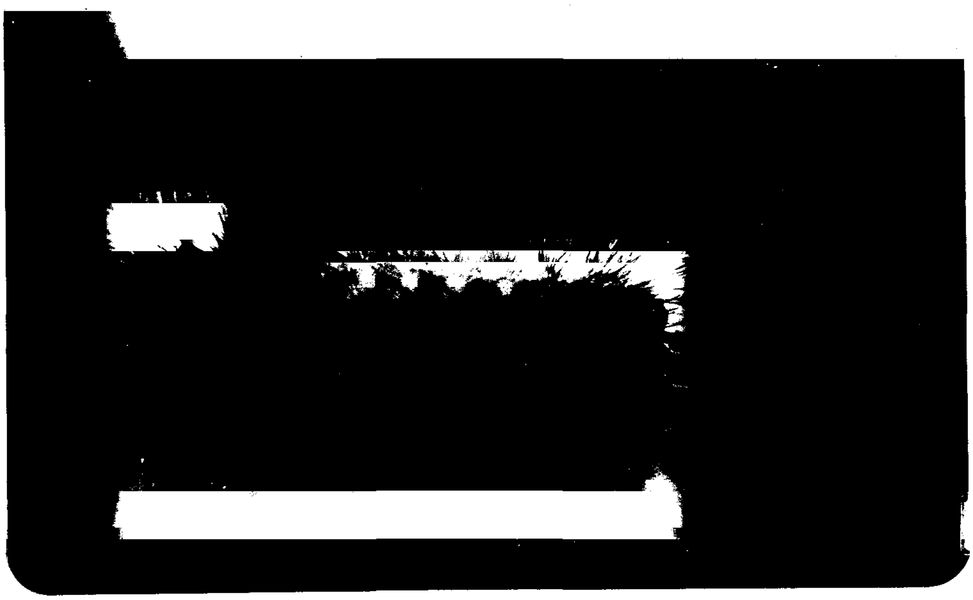


FIG. 8

Plate-V

Fig. 9. Male pupa of *D. obliqua* (X 0.36 mm).

Fig. 10. Female pupa of *D. obliqua* (X 0.36 mm).

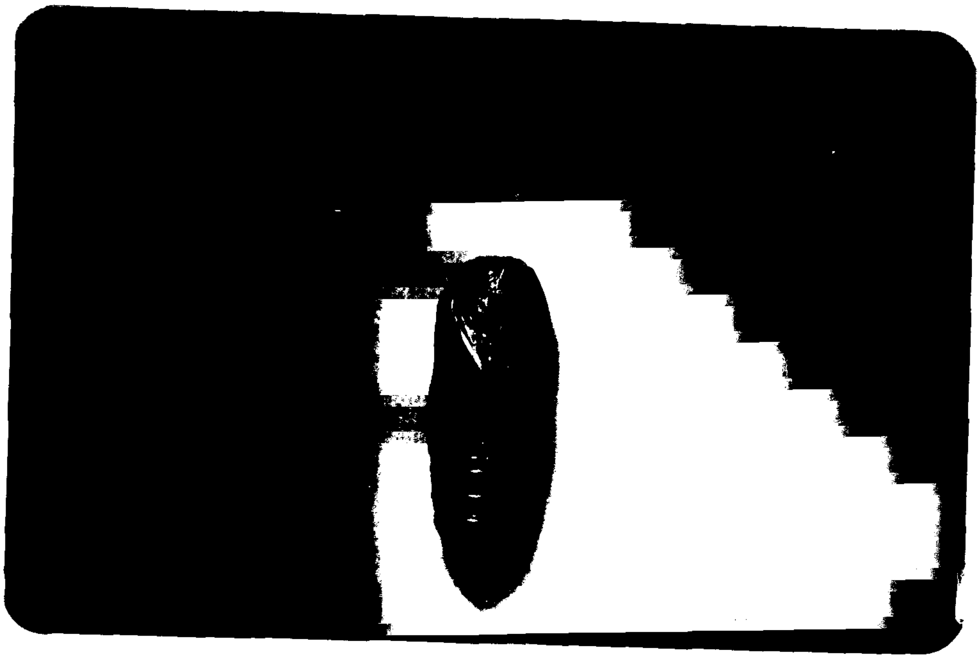


FIG.9

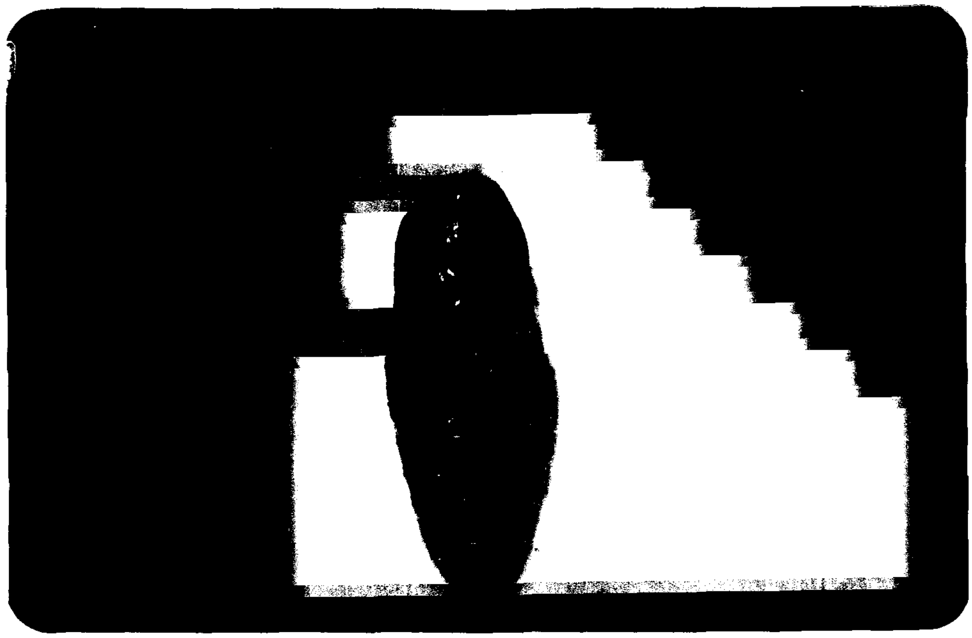


FIG.10

Plate-VI

Fig. 11. Adult male of *D. obliqua* (X 0.36 mm).

Fig. 12. Adult female of *D. obliqua* (X 0.48 mm).

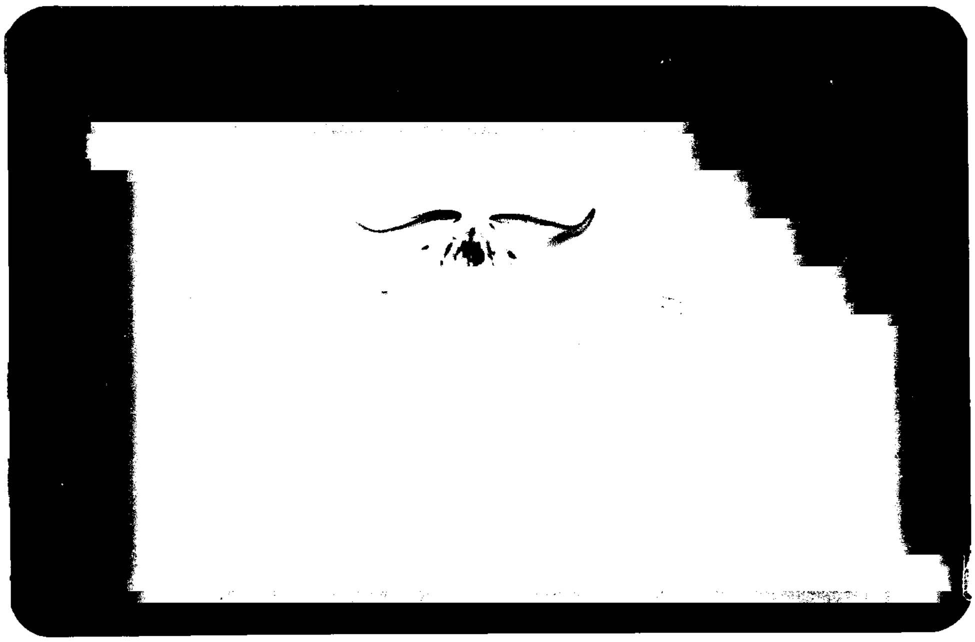


FIG. 11

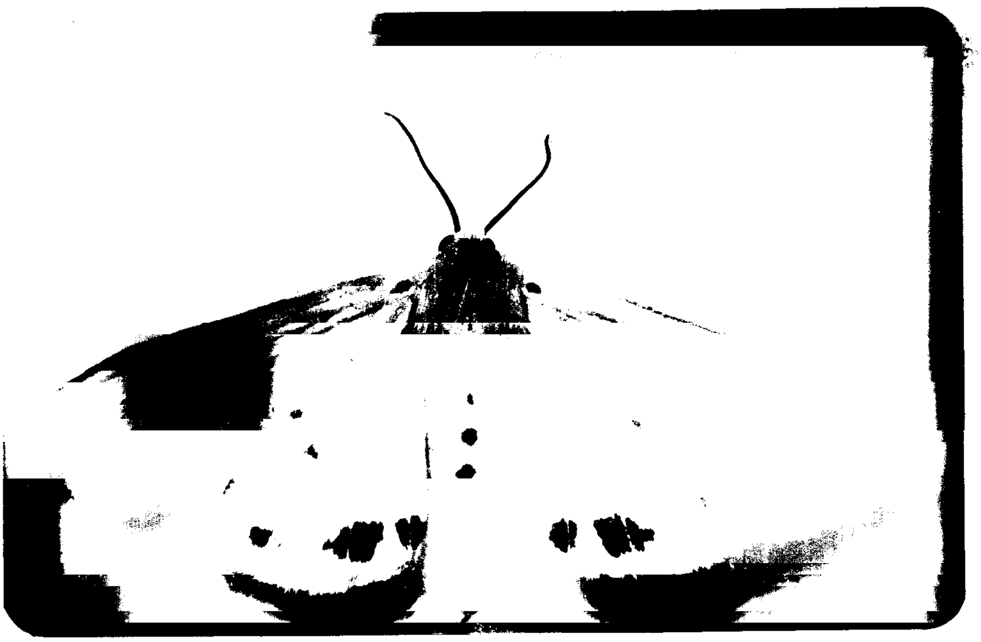


FIG. 12

FOOD CONSUMPTION AND UTILIZATION

Insects as a group feed upon a remarkably diverse list of organic substances. At the same time most species show a high degree of selectivity in their choice of food. According to Gordon (1959) "competition and natural selection gradually drive and bind each species to a specialised food supply that it can utilize more efficiently than any of its competitors". Although the quantitative nutritional requirements of growing insects seems to be uniform (Fraekel, 1953, 59; House, 1962). It seems apparent that adaptive nutritional differences must be sought on a quantitative level and that a meaningful comparative nutrition of insects will not emerge until quantitative studies are emphasised (Waldbauer, 1968).

The nutritional ecology of insects is the study related to the success of the insect in the ecosystem, host plant relationship and the survivalance of the pest in case of D. obliqua most of the work done in the area of nutritional ecology is on the food preference or on the insect plant relationship. But for the better understanding of the life history phenomenon like growth development and reproduction, it becomes essential to study the food consumption and utilization indices. The amount, rate and the quality of the food consumed by the larvae and the adults determine its performance of mating success, timing and extent of reproduction, dispersal ability and the probability of survival and the quality of off springs produced. Thus the consumption and utilization link the physiological, behavioural, ecological and the evolutionary aspects of insect life. Looking into the immense importance of the nutritional ecology, the present work was undertaken.

RESULTS

Consumption Index (C.I.) :

The consumption index explains the rate at which nutrients enter into the digestive system. The feeding is basically governed by the massiveness of the food, water content and other physico-chemical properties of the food material. Therefore the rate of intake of food is a function of response to feeding. The amount of food consumed increases from third to the last instar with slight decrease in the fifth instar (Table - 3, Fig. 20) the consumption index shows an alternating decrease and increase in successive developmental stages (Table - 4, Fig. 15).

Growth Rate (G.R.) :

The growth rate explains how much of dry matter increased in the body of the insect per day per mg of the body weight. It directly affects the speed of development which depends on the quality of the food, physiological stage and the environmental factors. The initial instars show higher growth rate which gradually goes on decreasing in successive developmental stages therefore it is negatively related to the stage of development (Table - 4, Fig. 16).

Efficiency of conversion of ingested food (ECI) :

The efficiency of conversion of ingested food basically depends on the amount of food eaten and the weight gained by the larvae. The ECI values decrease in the subsequent developmental stages proceeding from third to the sixth instar larvae with a slight increase in the fifth instar larvae. The third instar larvae show the maximum ECI value thus making an alternating pattern of increase and decrease (Table - 4, Fig. 18).

Efficiency of conversion of digested food (ECD) :

The efficiency of conversion of digested food meaning the amount of energy devoted for the maintenance of physiological functions of the insect. The observations reveal that the maximum amount of energy is used in the fourth instar larvae and the least is consumed by the third instar larvae (Table - 4, Fig. 19). The ECD values considerably decrease in the fourth instar making the remaining values higher, otherwise the pattern is a decrease down the table.

Approximate Digestibility (A.D.) :

The approximate digestibility is the function of the food ingested and the waste ejested. The AD value is lowest in the third instar which increases significantly in the fourth instar and then decreases in the following instars (Table - 4, Fig. 17). Although the food consumption generally increases with age but the digestibility fluctuates. The shoot up in the AD values can be attributed to the required storage of the food for the prepupal and the pupal stages during which they do not feed.

The dry weight of the subsequent larval instars show a gradual increase but the difference between the minimum and the maximum values is not very high. Whereas the increase in the fresh weight of the larval instars initially increases slowly but it shoots up suddenly in the last two i.e. V and VI instars. This shoot up is probably because of the excess food consumed which contains very high water content (Fig. 21).

The relative increase in the size and weight do not follow the Dyars law and Pirzibrams rule. The size increases slowly in the beginning and shoots up in the III, IV and the V instar than slightly increases in the last instar. Whereas the weight increases gradually with a constant speed upto the IV instars and then shoots up in the last two instars (Fig. 22).

Table - 3 : Showing the average fresh and dry weight of the larvae, food consumed, excreta voided and the weight gained by the III-VI instar larvae of *D. obliqua* after three days of feeding.

LARVAL INSTAR	AVE. FRESH WT. OF THE LARVA DURING FEEDING (mg)	AVE. DRY WT. OF THE LARVA DURING FEEDING (mg)	DURATION OF FEEDING PERIOD (days)	AVE. DRY WT. OF FOOD CONSUMED BY THE LARVA (mg)	AVE. DRY WT. OF THE FECES PRODUCED DURING FEEDING (mg)	AVE. DRY WT. GAINED BY THE LARVA DURING FEEDING (mg)
III	162.4±28.26	38.52±21.17	3	110.6±6.67	89.69±8.31	25.97±1.93
IV	191.18±34.52	50.6±17.88	3	302.86±41.34	136.86±11.61	32.62±17.71
V	256.64±12.18	77.4±48.81	3	189.3±24.73	125.34±41.94	33.59±25.55
VI	503.37±18.63	117.61±48.75	3	450.86±25.54	313.56±55.82	41.37±48.79

Table - 4 : Showing the consumption index, growth rate approximate digestibility, and efficiencies of conversion of ingested and digested food of _D. obliqua_.

LARVAR INSTAR	CONSUMPTION INDEX (C.I.) ± SE	GROWTH RATE (G.R.) ± SE	APPROXIMATE DIGESTIBI-LITY (A.D.) ± SE	EFFICIENCY OF CONVERSION OF INGESTED FOOD (E.C.I.) ± SE	EFFICIENCY OF CONVERSION OF DIGESTED FOOD (E.C.D.) ± SE
III	0.96±0.02	0.22±0.01	23.54±02.83	18.94±00.90	125.73±90.24
IV	2.05±0.09	0.21±0.01	11.00±04.42	54.79±04.23	020.21±16.32
V	0.82±0.19	0.14±0.03	18.27±20.14	34.39±00.07	051.60±29.11
VI	1.31±0.11	0.11±0.01	10.30±11.50	27.61±69.47	049.55±65.64

DISCUSSION

It has been observed that the food intake and the weight gained by the larvae is directly correlated with the age. Thus as the larvae grow older and enter into subsequent instars, gain comparatively more weight and consume more food (Bhat & Bhattacharya, 1978; Prasad & Chand, 1980; Warrington, 1985 and Sharma & Tara, 1988). Similar results have been found in the present study but there is slight fluctuation in the food consumption value of the fifth instar larva.

The consumption index, which is the rate of food intake per unit weight per day gradually decreases with age (Babu et al., 1979). However, in the present study there is a slight increase in the CI value of the fourth and the sixth instar thus presenting an alternating pattern of increase and decrease. The decreasing trend has been reported in Podius maculiventris (Mukerjee & LeRoux, 1969), Schistocerca gregaria and Locusta migratoria (Mehrotra et al., 1972) in Spodoptera litura (Prasad, 1973; Bhat & Bhattacharya, 1978) and in S. litura and D. obliqua (Sharma & Tara, 1988).

The growth rate determines how much of dry matter increased in the body of the organism per day per unit weight of the body. In the present study the growth rate show decreasing trend with the advancement of age. Similar patterns have been observed in L. decemlineata (Chlondy, 1967), L. migratoria (Bennakkars et al., 1970), L. migratoria and S. gregaria (Mehrotora et al., 1972), S. litura (Bhat & Bhattacharya, 1978) and in S. litura and D. obliqua (Sharma & Tara, 1988).

The approximate digestibility in Lepidopterans is found to fall in the subsequent instars (Waldbauer, 1968; Kogan & Cope, 1974; Mathavan & Bhaskaran, 1975; Mackey, 1978; Haukioja et al., 2978; Valentine & Talerico, 1980; Warrington, 1985). Similar pattern have also been reported among Acridids (Mordue & Hill, 1970; Mehrotra et al., 1972; Khalsa, 1973; Gupta & Vats, 1980 and Vir & Jindal, 1983). But in the present study the AD value increases in the fourth instar and then decreases in the remaining instars. Fluctuations in AD values have also been reported for Atractomorpha precautionis (Khalsa, 1973), Pseudoplusia includens (Kogen & Cope, 1974), S. litura (Bhat & Bhattacharya, 1978), S. litura and D. obliqua (Sharma & Tara, 1988).

The efficiency of conversion of ingested food varies considerably among the insects because it depends on the food consumed which is quite variable. In the present study there is a gradual decrease in the ECI values of the subsequent instars with a slight shoot up in the fifth instar. Similar patterns have been reported in A. precautionis (Khalsa, 1973), P. includens (Kogen & Cope, 1974) and S. litura (Bhat & Bhattacharya, 1978). In most of the Lepidopterans the ECI value tends to decrease with the advancement of age

(Waldbauer, 1968; Mackey, 1978 and Scriber, 1979) but this is not always the case, the ECI fluctuates irregularly with the final instar having the highest value (Mathavan & Bhaskaran, 1975). But in S. litura there is a gradual increase in ECI values but a sudden decrease in the final instar larva whereas in D. obliqua initially the value increases gradually and then decrease occurs in the fourth instar (Sharma & Tara, 1988).

The efficiency of conversion of digested food expresses the amount of energy devoted for the maintenance of physiological functions of the insect. In the present study the ECD value decreases with the advancement of developmental stages but their occurs slight increase in the fifth instar larva, it means the fifth instar requires more energy for its biological maintenance. Similar observations were reported for S. litura and D. obliqua (Bhat & Bhattacharya, 1978; Sharma & Tara, 1988). It has also been found that the ECD values fluctuate irregularly in the initial instars but increases in the fourth, fifth and the sixth instar (Mackey, 1978). The ECD gradually increases in later instars indicating that more energy is left for the growth and reproduction (Banerjee & Haque, 1984).

REFERENCES

Ahmad, M. and Ahmad, G. (1976). Morphological studies on the adults of Diacrisia obliqua Walker (Lepidoptera: Arctiidae). Pak. J. Zoo., 8(1): 1-11.

Ali, M.I. (1988). A survey of the insect pests of soybean in North Bangladesh, their damage and occurrence. Trop Pest. Manag., 34(3): 328-330.

Arai, T. and Mabuchi, M. (1979). Effects of light conditions on the timing of adult activities in Hyphantria cunea Drury (Lepidoptera : Arctiidae). Jap. J. Appl. Zool., 23(3): 162-169.

Atwal, A.S. (1986). Agricultural pests of India and South East Asia. Kalyani Publishers, New Delhi - Ludhiana, pp. 507.

Babu, M.H.; Bhattacharya, A.K. and Rathore, Y.S. (1978). Developmental behaviour of three Lepidopterous pests on soybean and green gram. Z. Agnew. Ent., 85(1): 108-112.

Babu, M.H.; Bhattacharya, A.K. and Rathore, Y.S. (1979). Rate of intake, growth and digestibility of three Lepidopterous insects. Z. Agnew. Ent., 87(3): 322-327.

Bakhetia, D.H.C. and Brar, K.S. (1982). Pest control in rapeseed and mustard. Ind. Farm., 32(8): 60-63.

Bakhetia, D.R.C. (1986). Control of insect pest of Toria sarson and Rai. Ind. Farm., 36(4): 41-44.

Banerjee, T.C. and Haque, N. (1984). Dry matter budgets for Diacrisia casignetum larvae fed on sunflower leaves. J. Insect Physiol., 30(11): 861-866.

Banerjee, T.C. and Haque, N. (1985). Stability and utilization of sunflower and climbing hemp-weed leaves by Diacrisia casignetum larvae. Syst. Oekol. Tiere., 112(1): 1-9.

*Banerji, B. (1971). Eclosion and oviposition rhythms of Andraca bipunctata Walker (Bombycidae : Lepidoptera) with a model for determining theoretical moth densities from eclosion rate. Indian J. Ent., 33(4): 411-418.

Bennakkars, M.A.; Meison, H.Q. and Scheras, J.M.J.D. (1970). Influence of temperature and food on growth and digestion of fifth instar larvae and adult of Locusta. J. Insect Physiol., 17(11): 871-883.

*Benson, C.F.C. and Chatterjee, N.C. (1940). Possibilities of control of Lantana (Lantana aculeata Linn.) by indigenous insect pests. Ind. For. Rec. (N.S. Ent.)., **6(3)**: 39-84.

Bhardwaj, S.P. and Bhalla, O.P. (1977). Record of insect pests of soybean in Himachal Pradesh. Indian J. Ent., **38(3)**: 286-289.

Bhat, N.S. and Bhattacharya, A.K. (1978). Consumption and utilization of soybean by Spodoptera litura (Fabricius) at different temperatures. Indian J. Ent., **40(1)**: 16-25.

Butani, D.K. and Juneja, S.S. (1984). Pest of raddish in India and their control. Pesticides, **18(5)**: 10-12.

Chand, P. (1979). Utilization of food by Bihar hairy caterpillar, Diacrisia obliqua Walker. Indian J. Ent., **41(3)**: 237-239.

Chaudhary, R.R.P. and Bhattacharya, A.K. (1986). Bioecology of Lepidopterous insects on winged bean, Psophocarpus tetrogonolobus (Linnaeus) DeCandole. Mem. Int. Soc. Ind., **11**: pp. 130.

*Chlondy, J. (1967). The amount of food consumed and production output of larvae of colorado beetle (Leptinotarsa decemlineata) Say.). Ekologia Polska - Seria A., **15**: 531-541.

Cohen, A.C. and Patana, R. (1984). Efficiency of food utilization by Heliothes zea (Lepidoptera : Noctuidae) fed on artificial diets or green beans. Can. Entomol., **116(2)**: 139-146.

Crocomoard, W.B. and Parra, J.R.P. (1985). Consumption and utilization of millet, wheat and sorghum by Spodoptera frugiperda (Smith) (Lepidoptera : Noctuidae). Rev. Bras. Entomol., **29(2)**: 225-260.

Deka, N.K.; Prasad, D. and Chand, P. (1987). Succession and incidence of insect pests in chick pea, Cicer arietinum L. Gornale Italiano di Ent., **3(17)**: 421-428.

Deshmukh, P.D.; Rathore, Y.S. and Bhattacharya, A.K. (1978). Effect of temperature and larval food on the head capsule of Diacrisia obliqua Walker. Indian J. Ent., **39(4)**: 333-340.

Deshmukh, P.D.; Rathore, Y.S. and Bhattacharya, A.K. (1982). Effect of temperature on the growth and development of Diacrisia obliqua (Walker) on five host plants. Indian J. Ent., **44(1)**: 23-32.

Dhuri, A.V.; Singh, K.M. and Singh, R.N. (1984). Incidence of insect pests in blackgram, Vigna mungo (L.) Hepper. Indian J. Ent., **46(3)**: 270-276.

*Gangrade, G.A. (1976). Terminal technical report on the project on assessment of effects on yield and quality of soybeans caused by major Arthropod pests Jabalpur, India. J.N. Krishi Vishwa Vidyalaya, 5; pp. 144.

Gangrade, G.A.; Singh, O.P. and Matkan, S.M. (1977). Soybean yield losses in response to damage by varying levels of three Lepidopterous larvae. Indian J. Ent., 37(3): 225-229.

Gargav, V.P. and Katiyar, O.P. (1971). Some new hosts of Diacrisia obliqua at Raipur, Madhya Pradesh. Indian J. Hort., 28(4); pp. 316.

Goel, S.C. and Kumar, A. (1983). Studies on the morphology of the larval instars of Diacrisia obliqua (Wlk.) (Lepidoptera : Arctiidae). Ann. Ent. Soc. Qubec., 28(1): 2-12.

Goel, S.C.; Kumar, A. and Singh, J. (1986). Variation in nutritional behaviour of hairy caterpillars, Diacrisia obliqua (Wlk.) (Arctiidae) and Lymantria marginata Wlk. (Lymantriidae). U.P.J. Zool., 6(2): 215-223.

*Gordon, H.T. (1959). Minimal nutritional requirements of the German roach, Blatella germanica L., Ann. A.Y. Acad. Sci., 77: 290-351.

Gupta, A. and Vats, L.K. (1980). Food consumption, assimilation and tissue growth in Phlaeoba infumata (Orthoptera : Acrididae). Indian J. Ecol., 7(1): 61-70.

Gupta, B.M.; Dabi, R.K.; Gupta, H.C. and Sharma, S.K. (1979). Effect of host plant on the larval development of Diacrisia obliqua Walker. J. Entomol. Res., 3(2): 224-226.

Gupta, S.C. (1982). Effect of food on the development of Diacrisia obliqua Walker. Geobios., 9(5): 215-219.

Haq, M.; Karim, A.N.M.R. and Alam, S. (1984). Preliminary study of varietal reaction of soybean cultivars to leaf defoliators. Trop. Grain, Leg. Bull., 29: 35-37.

Haq, M.; Karim, A.N.M.R. and Alam, S. (1985). Preliminary study of varietal reaction of soybean cultivators to leaf defoliators. Trop. Grain, Leg. Bull., 30: 29-30.

*Haukioja, E.; Niemela, P.; Iso-Ivori, L., Ojala, H. and Aro, E.M. (1978). Birch leaves as a resource for herbivores I. Variation in the suitability of leaves. Report of the Kevo Subartic Res. Stat., 14: 5-12.

*House, H.L. (1962). Insect Nutrition. Rev. Biochem., 31: 653-672.

Hussain, T. (1982). Mating behaviour and oviposition of Diacrisia obliqua Wlk. (Lepidoptera : Arctiidae). Pak. J. Sci. Ind. Res., 25(6): 238.

Islam, B.N. and Alam, M.Z. (1980). Mating behaviour of Jute hairy caterpillar, Diacrisia obliqua Walker (Lepidoptera : Arctiidae) II. Rate of catch of male moth by virgin female traps. Appl. Ent. Zool., 15(3): 299-309.

Islam, W.; Ahmad, K.N.; Nargis, A. and Islam, U. (1983). Occurrence, abundance and extent of damage caused by insect pests of groundnut (Arachis hypogaea). Malaysia Agril. J., 54(1): 18-24.

Kabir, A. and Miah, H.A. (1987). Effect of certain food plants on the growth and development of Jute hairy caterpillar, Diacrisia obliqua Walker. Bangladesh J. Zool., 15(2): 177-182.

Kapoor, K.N.; Gujarati, J.P. and Gangrade, G.A. (1972). Bionomics of Lamprosema indicata Fabricius (Lepidoptera : Pyralidae) a pest of soybean in Madhya Pradesh. Indian J. Ent., 34(2): 102-105.

Khaleque, M.A. (1983). Soybean seed quality and standard establishment in Bangladesh. Proc. Conf. Scit. Asia. 25-31.

*Khalsa, M.S. (1973). Host plant selection behaviour of Autographa precautionis (Guence) (Lepidoptera : Noctuidae). Ph.D. thesis, Univ. of Illinois, Urbana, Illinois, U.S.A., pp. 286.

Kogan, M. and Cope, D. (1974). Feeding and nutrition of insects associated with soybean 3. Food intake, utilization and growth in the soybean looper, Pseudoplusia includens. Ann. Entomol. Soc. Am., 66: 66-72.

*Krishnah, K.; Prasad, V.G. and Mohan, N.J. (1975). New records of alternate hosts of Tobacco caterpillar, Spodoptera litura (Fab.) (Lepidoptera : Noctuidae) and Bihar hairy caterpillar, Diacrisia obliqua Wlk. (Lepidoptera Arctiidae). Currt. Sci., 44(4): 304-312.

*Krishnamurthy, M.M.; Sayi, I.V. and Rao, B.H.K.M. (1974). Notes on the biology of shoot and blossom webber, Mocalla moncusalis Walker (Lepidoptera : Pyralidae) of cashew. Indian J. Ent., 36(1): 76-77.

Lal, L. and Mukherji, S.P. (1978). Growth potential of Diacrisia obliqua Walker in relation to certain food plants. Indian. J. Ent., 40(2): 177-181.

Lal, S.S. (1985). A review of insect pests of mung bean and their control in India. Trop. Pest Manag., 31(2): 105-114.

Mackey, A.P. (1978). Growth and bioenergetics of the moth, Cyclophragma leucosticta Gruneberg. Oecologia (Berl.),32: 367-376.

Martinez, E.; Novo Padrino, J.M. and Hernandez, H.F. (1986). Life cycle of Heliothes virescens Fabricius (Lepidoptera : Noctuidae) under ambient conditions in the laboratory. Centro Agricola, 11(2): 39-45.

*Mathavan, S. and Bhaskaran, R. (1975). Food selection and utilization in a Danid butterfly. Oecologia (Berl.), 18: 55-62.

*Mathur, A.C. (1962). Food plant spectrum of Diacrisia obliqua Wlk. (Lepidoptera : Arctiidae) infesting medicinal plants in Jammu. Indian J. Ent., 24(3): 286-287.

*Mehra, B.P. and Shah, B.N. (1966). Bionomics of Hemithea tritonaria Walker (Lepidoptera : Geometridae), a pest of Moghania macrophylla (Wild.) O. Ktze. Indian J. Ent., 28(4): 345-350.

Mehra, B.P. and Shah, B.N. (1970). Bionomics of Thiacidas postica Walker (Lepidoptera : Noctuidae), a pest of Ziziphus mauritiana Lamarck. Indian J. Ent., 32(2): 145-151.

Mehrotra, K.N.; Rao, P.J. and Farooki, T.N.A. (1972). The consumption and utilization of food by locusts. Entomol. Exp. Appl., 15: 90-96.

*Mordue (Luntz), A.J. and Hill, L. (1970). The utilization of food by adult female desert locust, Schistocerca gregaria. Entomol. Exp. Appl., 13: 352-358.

*Mukerjee, M.K. and LeRoux, E.J. (1969). A quantitative study of food consumption and growth of Podius maculiventris (Hemiptera : Pentatomidae). Can. Entomol., 101: 387-409.

Murad, H. (1969). Morphology and life history of Lepidopterous insect with some observations on the food selection behaviour of the larva. Ph.D. thesis, Aligarh Muslim University, Aligarh, India, pp. 243.

Nikolov, N.K. (1980). The role of soil moisture in the development of some species of genus Agrotis (Lepidoptera : Noctuidae). Rasteniew dni Nauki., 17(2): 102-110.

Pachori, R.; Rathore, V.S.; Rawat, R.R.; Jakhmola, S.S. and Khatri, A.K. (1980). Economic threshold of Diacrisia obliqua Wlk. on groundnut. Indian J. Agril. Sci., 50(1): 69-72.

Palaniswami, M.S. and Pillai, K.S. (1981). Two hairy caterpillars as pests of Coleus. J. Root Crops., 7: 79-80.

Pandey, N.D.; Mishra, S.C. and Pandey, U.K. (1978). Some observations on the biology of Polymatus boeticus Linn. (Lepidoptera : Lycaenidae) a pest of Cajanus cajan L. Millsp., Indian J. Ent., 40(1): 41-82.

*Pandey, N.D. and Pandey, Y.D. (1964). Bionomics of Phyllocnistis citrella Stt. (Lepidoptera : Gracillaridae). Indian J. Ent., 26(4): 415-422.

*Pant, N.C. (1964). Entomology in India. Silver Jubilee Number of Indian J. Ent., pp. 529.

*Prasad, D. and Prem Chand (1980 a). Growth and development of Diacrisia obliqua Walker on various food plants. Indian J. Ent., 42(4): 611-616.

Prasad, D. and Prem Chand (1980 b). Some observations on the moulting behaviour and larval mortality of Diacrisia obliqua Walker on different food. Indian J. Ent., 42(4): 826-828.

*Prasad, J. (1973). Growth and development of the Tobacco caterpillar, Spodoptera littoralis (Biosduval) (Lepidoptera : Noctuidae) on several host plants. M.Sc. thesis, G.B.P.U.A. & T. Pantnagar, India, pp. 123.

Puttaswami; Gowda, B.L.V. and Ali, T.M.M. (1977). Record of pests infesting moth bean (matki) (Phaseolous acontifolius Jacq.), a potential pulse crop. Currt. Res., 6(4): 69-71.

Puttaswami and Reddy, D.N.R. (1981). Record of some new pests infesting French bean (Phaseolous vulgaris L.),a popular vegetable. Currt. Res., 10(3): 39-41.

Ram, S. and Bhattacharya, A.K. (1978). Consumption of soybean by Diacrisia obliqua Walker. Indian J. Ent., 40(3): 335-336.

Rao, M.S. and Patel, C.R. (1973). Biology and control of Okra semilooper, Anomis flava Fabricius (Noctuidae : Lepidoptera) on okra. Indian J. Ent., 35(2): 198-205.

Rathore, Y.S. and Sachan, G.S. (1978). Developmental behaviour of Diacrisia obliqua (Walker) (Lepidoptera: Arctiidae) on some common weeds. Currt Sci., 47(3): 104-106.

Ripa, S.R. (1980). The cutworms, Euxoa bilitura (Guence) and E. lutescens (Blanchard) (Lepidoptera : Noctuidae) II. Studies on oviposition and development under laboratory conditions. Agril. Technica., 40(1): 38-41.

Rizzo, H.F. (1978). Morphology of the different stages of development of Spilosoma virginica (F.) (Lepidoptera Arctiidae). Rev. Soc. Ent. Arg., 35: 83-93.

Rizzo, H.F. (1979). Biology of Spilosoma virginica (F.) (Lepidoptera : Arctiidae). Rev. Soc. Ent. Arg., 38: 83-84.

Rohilla, H.R.; Singh, H.V.; Gupta, D.S. and Singh, K. (1981). Pest complex other than diseases of sunflower, Helianthus annus in Haryana. Ind. J. Plant Prot., 8(2): 177-182.

Sachan, G.C. (1981). Growth and development of Diacrisia obliqua Walker on some vegetables. Ind. Agril. Sci., 51(8): 579-582.

*Sachan, J.N. and Srivastava, B.P. (1965). Biology of the Lily moth, Polytella gloriosae Fabr. (Lepidoptera: Noctuidae). Indian J. Ent., 27(2): 137-139.

*Scriber, J.M. (1979). Effect of leaf water supplementation upon post ingestive nutritional indices of forb-, shrub-, vine and tree feeding Lepidoptera. Ext. Exp. Appl., 25: 240-252.

*Sengalevich, G. (1960). Spilosoma (= Spilarctia) lubricipeda L. a new pest of fruit trees. Rast. Zasht., 8: 69-72.

Sethi, G.R., Prasad, H. and Singh, K.M. (1979). Population build up of Diacrisia obliqua Walker on sunflower at Delhi. Indian J. Ent., 41(1): 36-38.

*Shah, B.N. and Mehra, B.P. (1966). Bionomics of Nephopteryx leucocephaella Zell. (Lepidoptera : Pyralidae) a pest of Moghania macrophylla (Wild.) O. Ktze., Indian J. Ent., 28(3): 442-447.

*Sharif, M. (1962). Jute pests and the possibilities of their adequate control. Jute & Jute Fabrics, 3: 63-70.

Sharma, B. and Tara, J.S. (1988). Comparision of consumption and utilization of mulberry leaves in two moths, Spodoptera litura (F.) and Diacrisia obliqua Walker. Indian J. Ent., 50(3): 336-342.

Siddiqi, J.I. (1985). Studies on reproduction III. Mating in Diacrisia obliqua Walker (Lepidoptera : Arctiidae). Indian J. Ent., 47(4): 411-415.

Siddiqi, J.I. (1988). Studies on reproduction IV. Oviposition in Diacrisia obliqua Walker (Lepidoptera : Arctiidae). Indian J. Ent., 48(3): 248-257.

Singh, H. and Singh, G. (1975). Biological studies on Heliothis armigera (Hubner) in Punjab. Indian J. Ent., 37(2): 154-164.

Singh, O.P. and Gangrade, G.A. (1974). Biology of Diacrisia obliqua Walker (Lepidoptera : Arctiidae) on soybean and effect of loss of chlorophyll on pod and grain. J.N.K.V.V. Res., 8(2): 86-91.

Singh, O.P. and Gangrade, G.A. (1977). Notes on the effect of constant temperature on the development of Bihar hairy caterpillar, Diacrisia obliqua Walker on soybean. Ind. Agril. Sci., 44(12): 900-901.

Singh, R. (1978). Field observations on copulation, pre-oviposition and oviposition periods of Amarasca bigutella bigutella (Ishida). Indian J. Ent., 40(1): 100.

Slansky, F. Jr. (1985). Food utilization by insects : Interpretation of observed differences between dry weight and energy efficiencies. Entomol. Exp. Appl. 39(1): 47-60.

Simpson, S.J. (1982). Changes in the efficiency of utilization of food throughout the V instar nymph of Locusta migratoria. Entomol. Exp. Appl., 31(3): 265-275.

Sinha, M.M.; Yazdani, S.S.; Kumar, A. and Singh, R. (1985). Observations on the seasonal occurrence of the insect pests of greengram (Phaseolus aureus Roxb.) in North Bihar. Bull. Ent., 26(2): 210-211.

*Srivastava, A.S.; Lal, J. and Saxena, H.P. (1965). Notes on the nature of damage, occurrence and incidence of insect pests of groundnut crops in U.P., Labdev, J. Sci & Tech., 3(2): 141-142.

Srivastava, A.S.; Srivastava, J.L. and Tripathi, R.A. (1972). Incidence of pests on castor. Labdev. J. Sci & Tech, 10(1): 47-48.

Srivastava, S.C. and Pandey, P.N. (1983). The effect of crucifers on growth, development, nutrition and reproduction of Diacrisia obliqua Walker (Lepidoptera : Arctiidae). Ind. J. Zootomy, 22(1): 35-46.

Srivastava, S.C. and Pandey, P.N. (1987). Establishment of Diacrisia obliqua Walker on certain plants of compositae. Indian J. Ent., 49(1): 7-15.

*Teotia, T.P.S. and Nand, S. (1966). Bionomics of the Rice skipper, Parnara mathias Fabricius (Lepidoptera : Hesperiidae). Indian J. Ent., 28(2): 181-186.

*Trehan, K.N. and Butani, D.K. (1949). Notes on life history, bionomics and control of Chino zonellus Swinhow in Bombay province. Indian J. Ent., 11(1): 47-59.

*Tripathi, R.L. (1967). Insects and other pests of Jute and their control measures. Jute Bull., 30(3): 90-98.

Valentine, H.T. and Talerico, R.L. (1980). Gypsy moth larval growth and consumption on red oak. For. Sci., 26: 599-605.

Velusamy, R. and Subramanium, T.R. (1974). Bionomics of the Rice leaf roller, Cnaphalocrocis medianalis Guen. (Pyralidae : Lepidoptera). Indian J. Ent., 36(3): 185-189.

Verma, G.D.; Singh, J.; Singh, I.P. and Lal, S.N. (1977). Record of the maize pests during Kharif at Dholi. Entomologist News Letter, 7(6): pp. 27.

Vir, S. and Jindal, S.K. (1983). A quantitative study of food consumption, assimilation and growth in the larvae of Crocidolomia binotalis Zell. (Lepidoptera: Pyralidae). J. Anim. Morphol. Physiol., 30(1): 20-26.

Vora, V.J.; Bharodia, R.K. and Kapadia, M.N. (1985). Pests of oil seed crops and their control on groundnut. Pesticides, 19(3): 19-22.

*Waldbauer, G.P. (1964). Consumption, digestion and utilization of Solonaceous and Non-Solonaceous plants by larvae of Tobacco hornworm, Protoparce sexta (Lepidoptera : Sphingidae). Entomol Exp. Appl., 7: 253-259.

Waldbauer, G.P. (1968). The consumption and utilization of food by insects. Adv. Inst. Physiol., 5: 229-288.

Warrington, S. (1985). Consumption rates and utilization efficiencies of four species of polyphagous Lepidoptera feeding on sycamore leaves. Oecologia (Berl.), 67: 460-463.

Webster, R.P. and Conner, W.E. (1986). Effect of temperature, photoperiod and light intensity on the calling rhythm in Arctiid moths. Entomol Exp. Appl., 40(3): 239-245.

Yadav, L.S. and Yadav, P.R. (1983). Pest complex of cowpea (Vigna sinensis Savi) in Haryana. Bull. Ent., 24(1): 57-58.

*Yadav, R.P.; Singh, R. and Kumar, A. (1978). Larval survival and growth potential of Diacrisia obliqua Walker in relation to some promising varieties of black gram. Indian J. Ent., 40(2): 146-149.

---

*Not seen in original.

Fig. 13. Showing the incubation period, larval and pupal durations in *D. obliqua*.

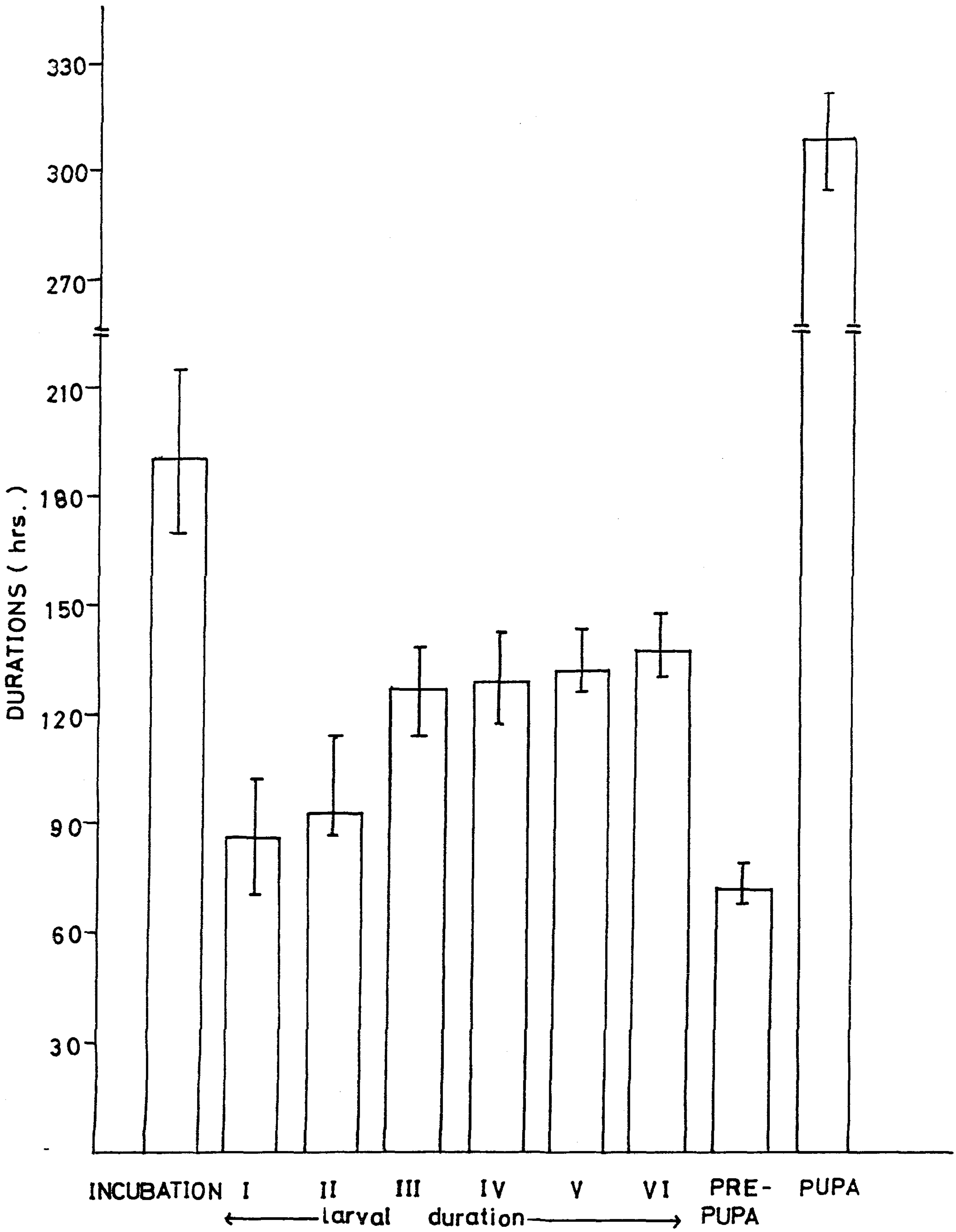

330
300
270
210
180
150
120
90
60
30
DURATIONS (hrs.)
INCUBATION
I
II
III
IV
V
VI
PRE-PUPA
PUPA
larval duration

FIG.13

Fig. 14. Showing the preoviposition, oviposition, postoviposition periods and the longevity of unmated and mated adults of *D. obliqua*.

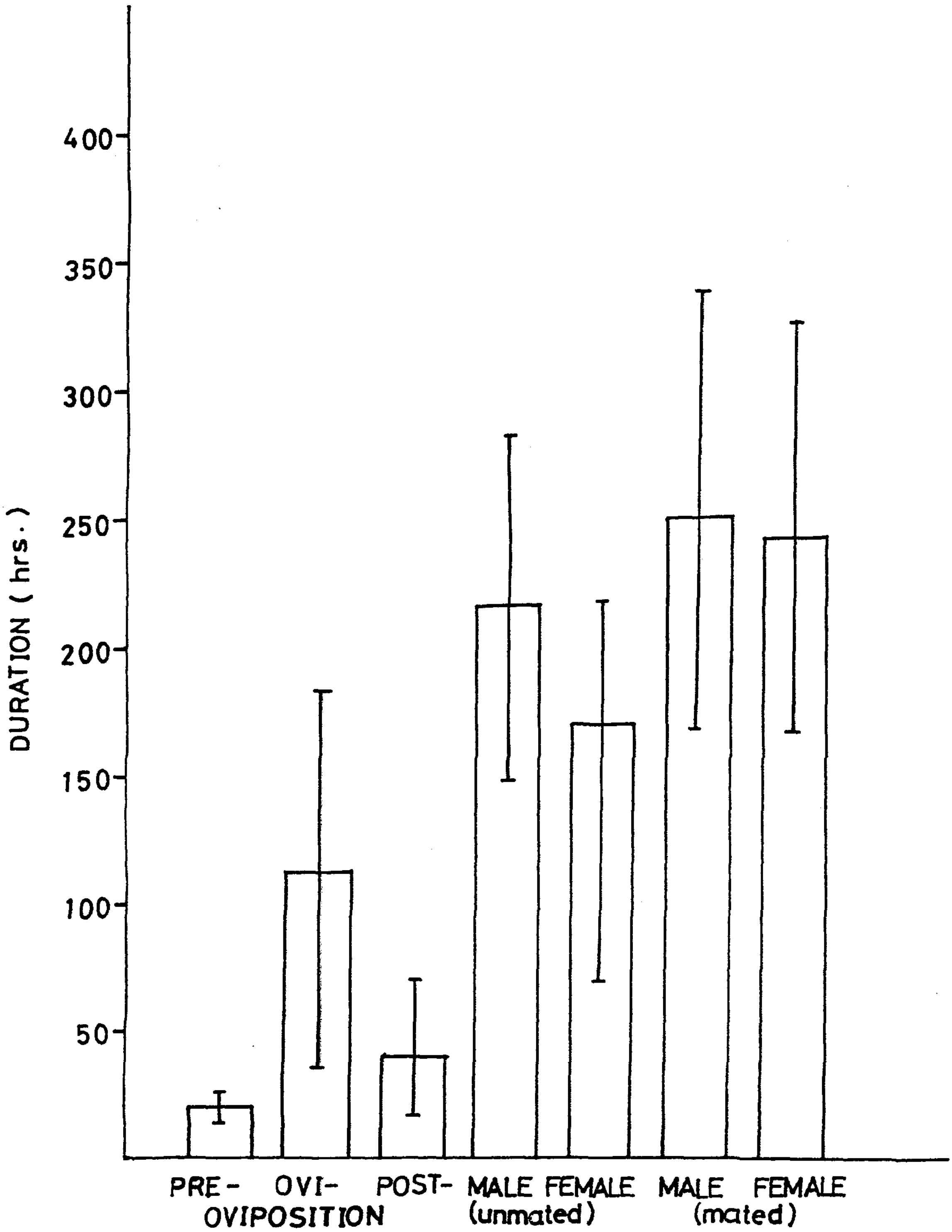

400
350
300
250
200
150
100
50
DURATION (hrs.)
PRE- OVI- POST-
OVIPOSITION
MALE FEMALE
(unmated)
MALE FEMALE
(mated)

FIG.14

Fig. 15. Showing the relationship between the consumption index (C.I.) and the larval stages of *D. obliqua*.

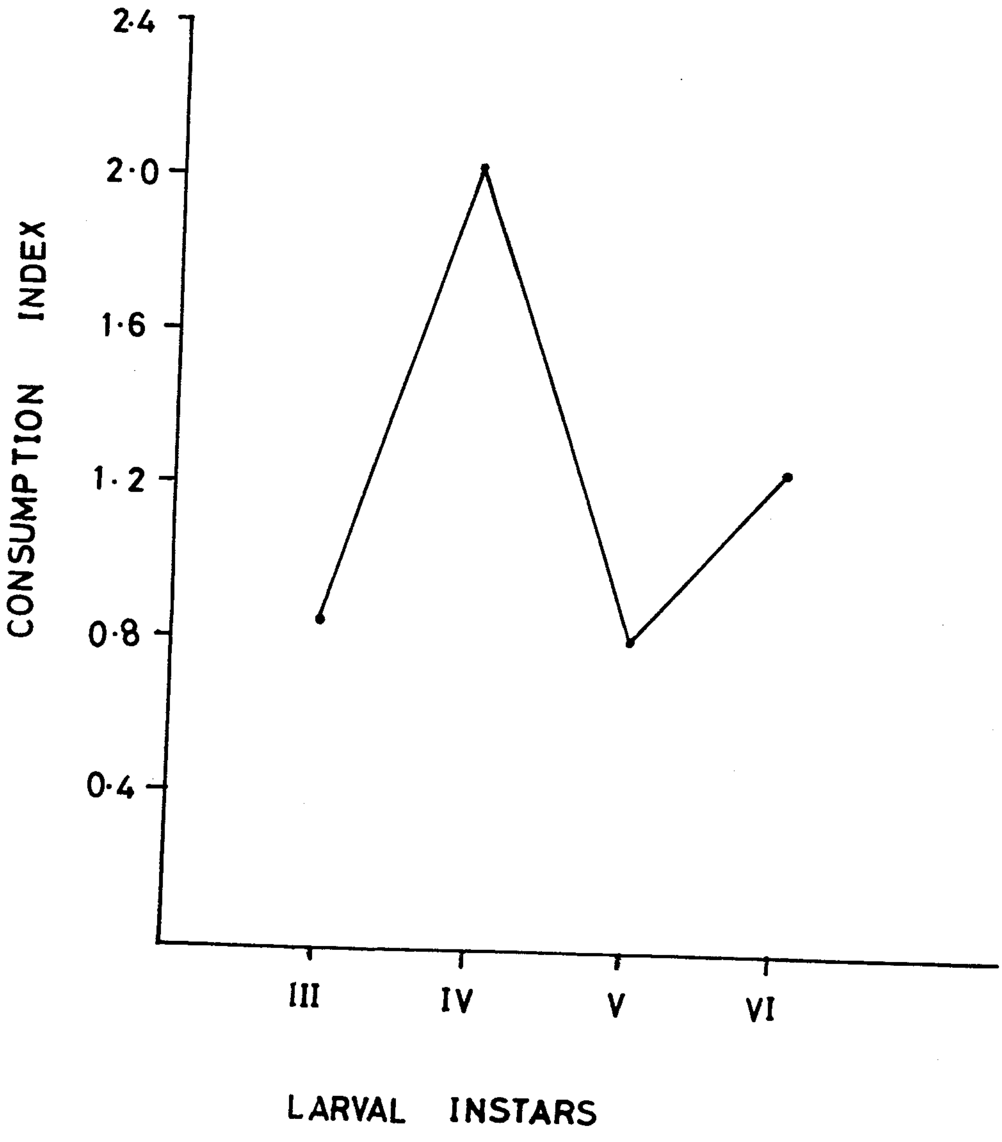


FIG.15

Fig. 16. Showing the relationship between the growth rate (G.R.) and the larval stages of *D. obliqua*.

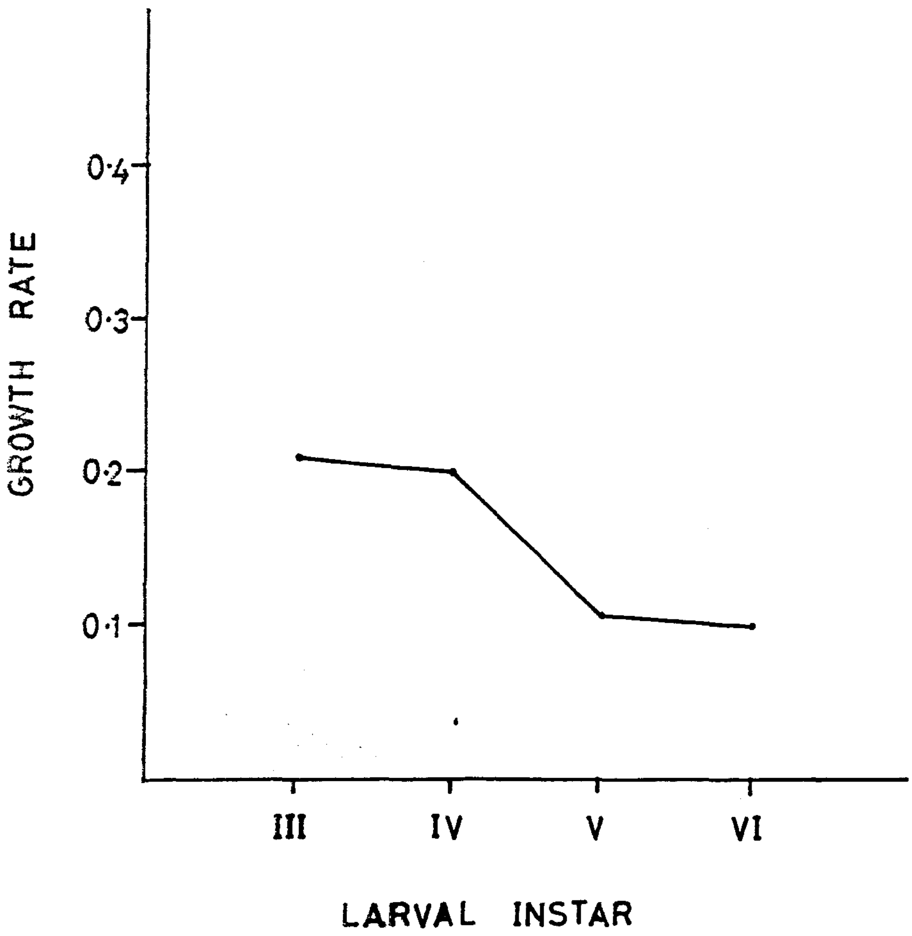


FIG.16

Fig. 17. Showing the relationship between the approximate digestibility (A.D.) and the larval stages of *D. obliqua*.

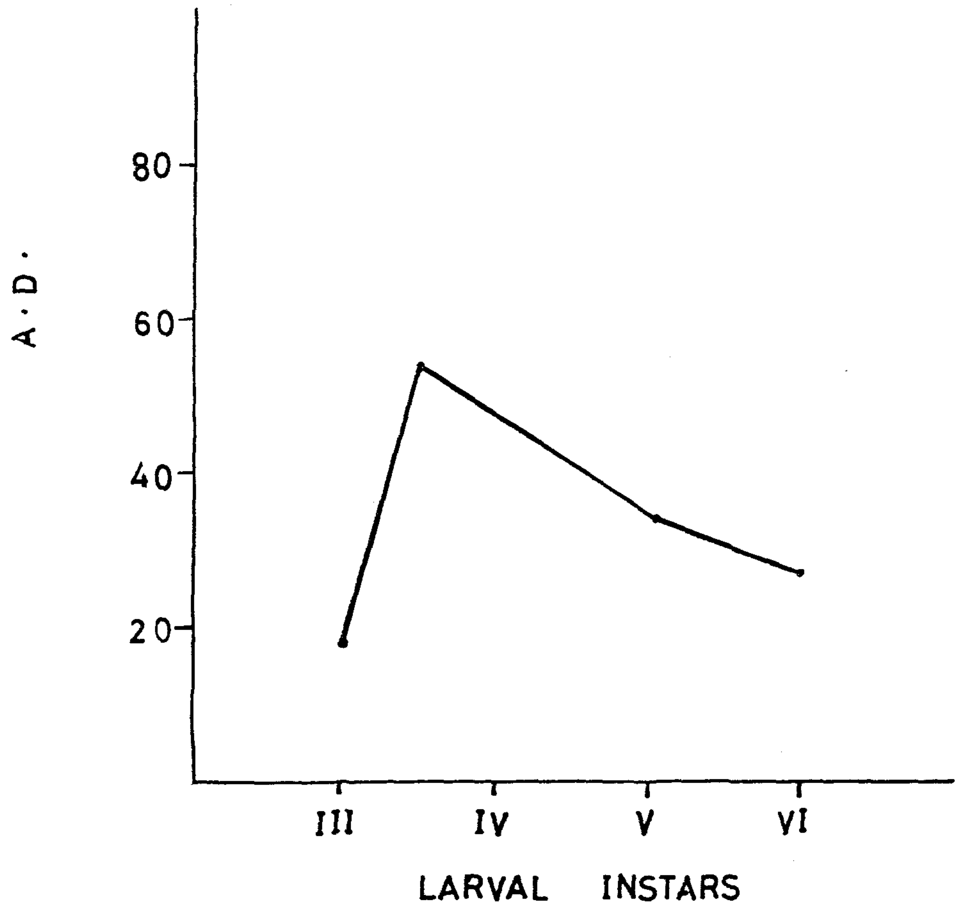


FIG. 17

Fig. 18. Showing the fluctuations in the values of efficiency of conversion of ingested food (E.C.I.) in the subsequent larval instars of *D. obliqua*.

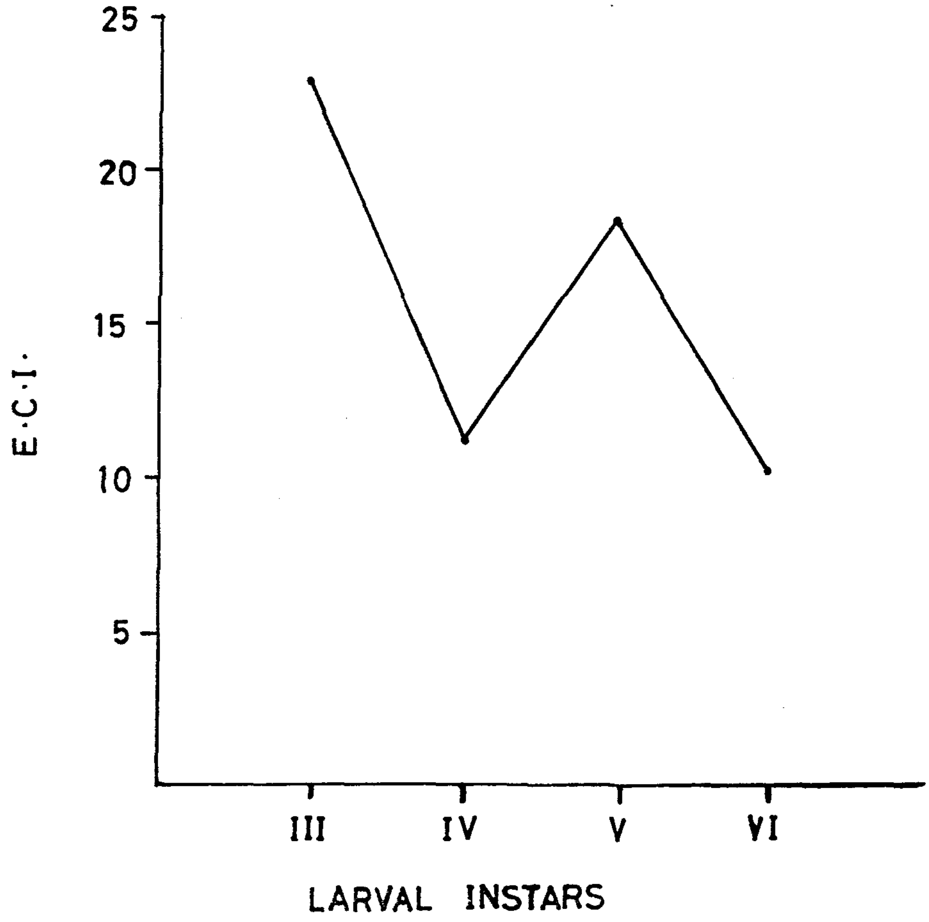


FIG.18

Fig. 19. Showing the fluctuations in the values of efficiency of conversion of digested food (E.C.D.) in the subsequent larval instars of *D. obliqua*.

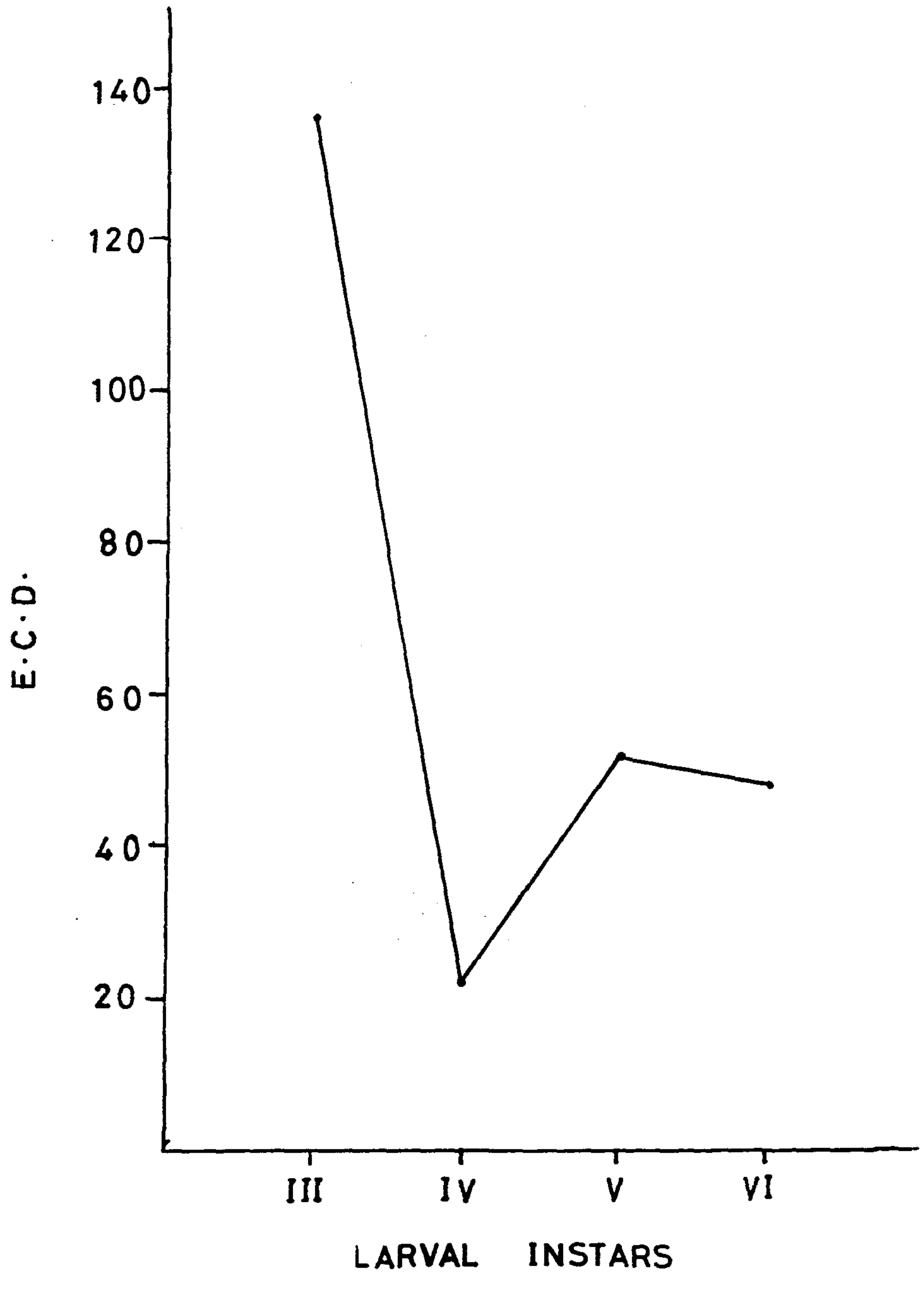
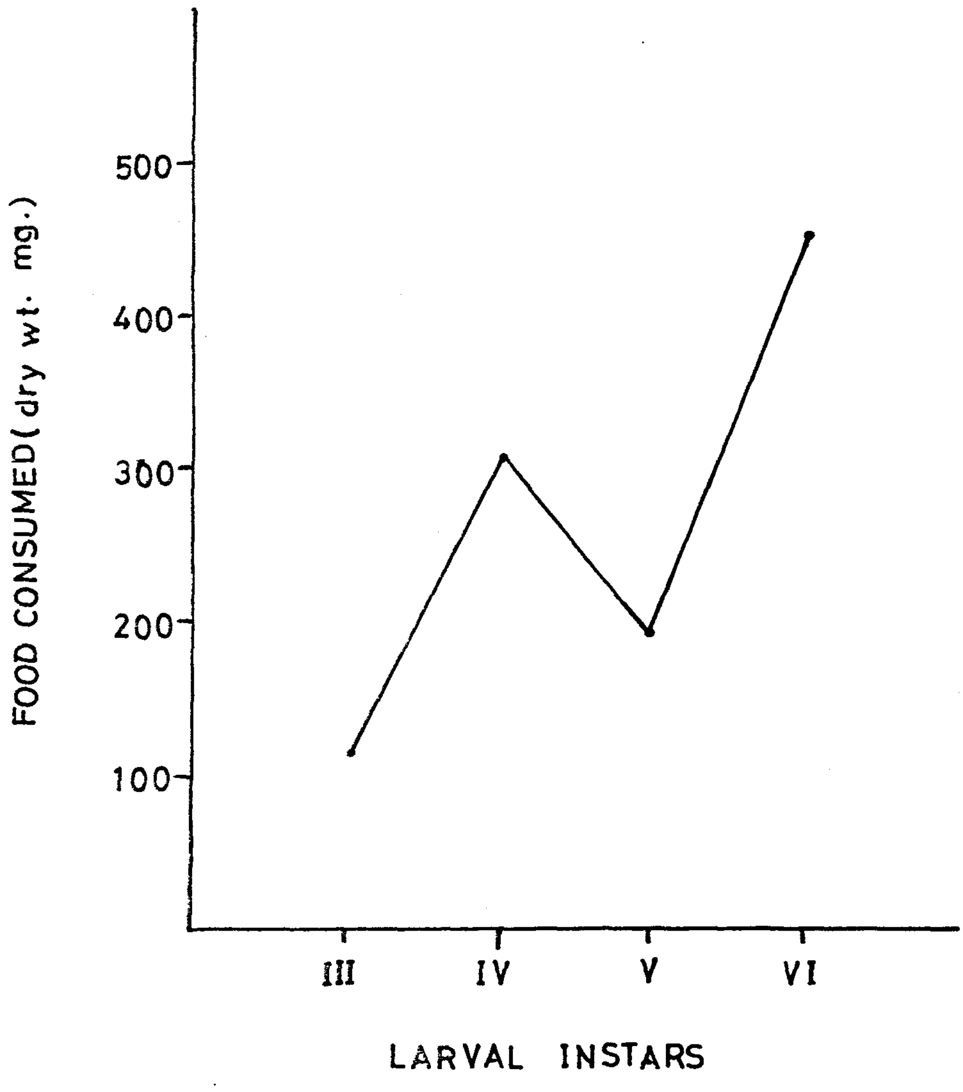


FIG.19

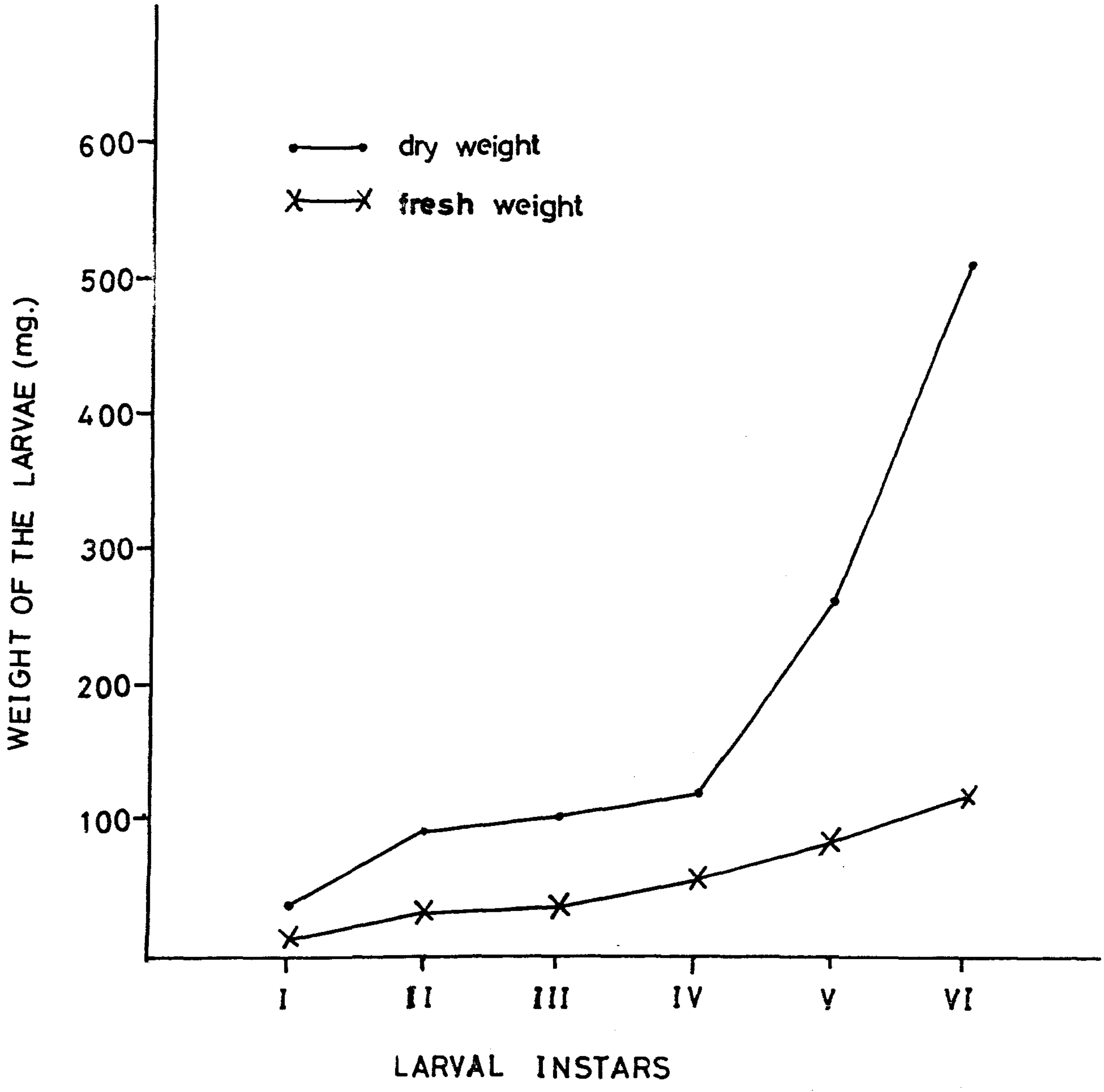
Fig. 20. Showing the relationship of food consumed in the subsequent larval instars of *D. obliqua*.



FOOD CONSUMED(dry wt. mg.)
500
400
300
200
100
III
IV
V
VI
LARVAL INSTARS

FIG. 20

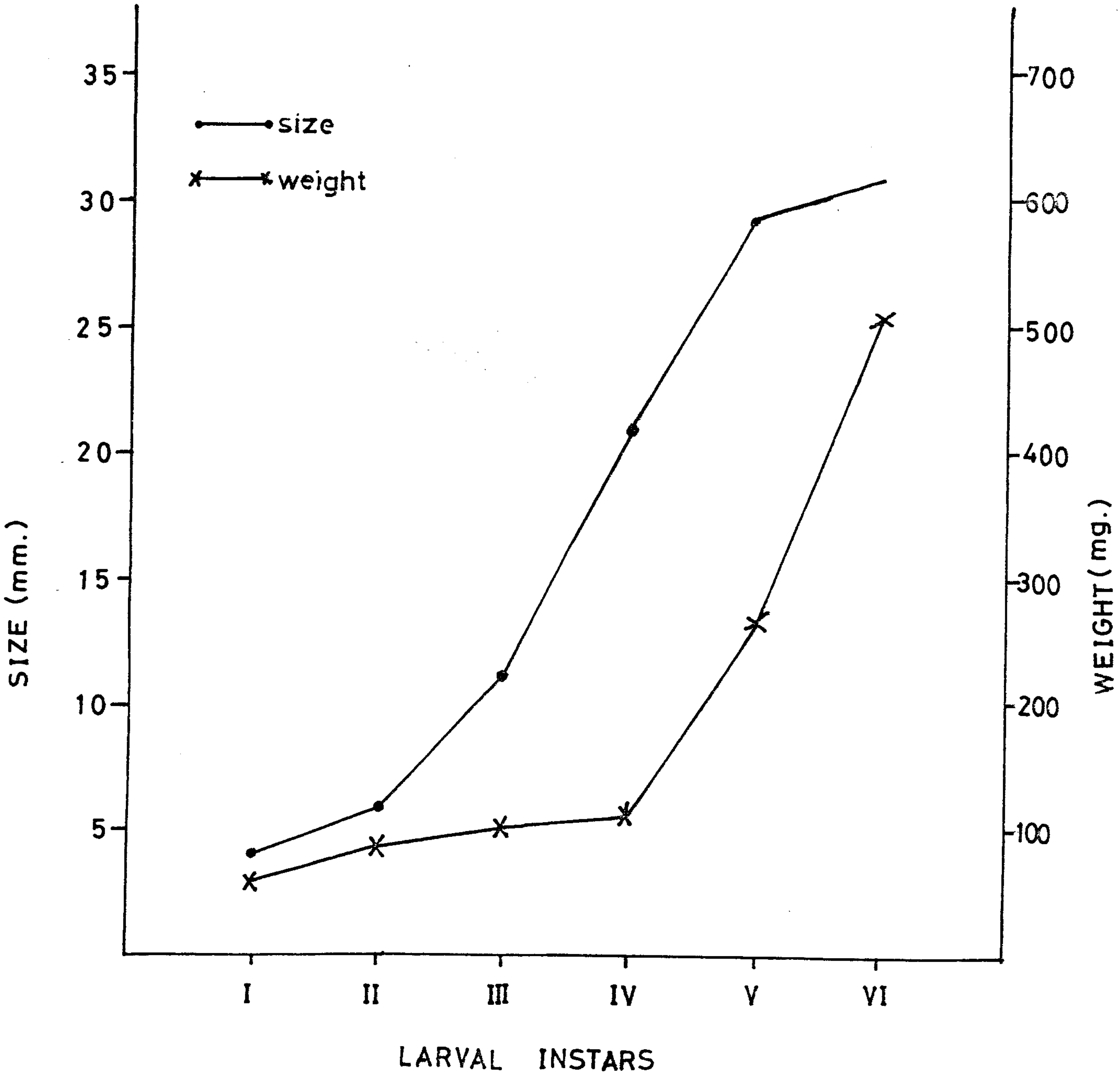
Fig. 21. Showing the relationship between fresh and dry weight in the subsequent larval instars of *D. obliqua*.



dry weight
fresh weight
600
500
400
300
200
100
WEIGHT OF THE LARVAE (mg.)
I
II
III
IV
V
VI
LARVAL INSTARS

FIG· 21

Fig. 22. Showing the relationship between the larval size and weight in the subsequent larval instars of *D. obliqua*.



size
weight
SIZE (mm.)
WEIGHT (mg.)
35
30
25
20
15
10
5
700
600
500
400
300
200
100
I
II
III
IV
V
VI
LARVAL INSTARS

FIG. 22